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DEPOT MAINTENANCE PARTS DEMAND DISTRIBUTION

AND

EVALUATION OF ALTERNATIVE STOCKAGE POLICIES

THESIS

Steven H. McBride

AFIT/GLM/LSM/88S-46

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DEPOT MAINTENANCE PARTS DEMAND DISTRIBUTION

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EVALUATION OF ALTERNATIVE STOCKAGE POLICIES

THESIS

Presented to the Faculty of the School of Systems and Logistics

of the Air Force Institute of Technology

Air University

In Partial Fulfillment of the

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Master of Science in Logistics Management

Steven H. McBride, B.S.I.E., P.E., CPIM

September 1988

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Table of Contents

		Page
Acknowledgements		ii
List of Figures		vi
List of Tables		vii
Abstract		viii
I.	Introduction	1
	General Issue	1
	Introduction	3
	Statistical Inventory Control Techniques	3
	Material Requirements Planning	4
	Statement of Problem	6
	Research Questions	6
	Scope of Study	7
II.	Background and Review of Literature	10
	Overview	10
	Depot Maintenance (MIC) Stockage	10
	Exchangeables Production System	11
	Depot Supply Stockage	13
	Intermediate Calculations	13
	D033 Formula	14
	Stock Computations	15
	Workload Projections	16
	MIC and DS Fill Rate Objectives	19
	Review of Literature	20
	Blazer	20
	RAND--Sherbrooke	24
	RAND--Brown	26
	RAND--Brown and Geisler	28
	Crowe and Lowman	29
	RAND--Hodges	29
	Shields	30
III.	Methodology	32
	Overall Approach	32
	Data Analysis	32
	Analysis of Actual Demands	32
	Distribution Parameters	33
	Variables for Analysis	35
	Data Collection	35
	Data Transformation	36

Demand Data Analysis 37
MIC Intransit Days 39
Determining Current Statistical Assumptions. 40
Determining MIC Demand Assumptions 40
Determining D033 VMR Assumptions 41
Simulation of Alternative Models 43
Experimental Design 43
Simulated Demand Data 43
SLAM II Model Logic 44
Experimentation 46

IV. *Findings and Analysis* 47

Overview 47
Data Analysis 47
Analysis of Actual Demand 47
MIC Intransit Days 54
Determining Current Statistical Assumptions 56
MIC Demand Assumptions 56
First Simulation 56
Second MIC Simulation 58
D033 VMR Assumptions 61
Simulation of Alternative Models 63
7/3.5 Day MIC Stockage Policy 63
Lot-for-Lot MIC Stockage Policy 64
Comparative Performance of Alternative Policies . 66

V. Conclusions and Recommendations 71
Research Summary 71
Research Conclusions 72
Methodology Issues 73
Suggestions for Follow-on Research 74
Recommendations 76

Appendix A: Sample of D033 "TVA" Report 77

Appendix B: Sample of Demand Data 78

Appendix C: TANDEM ENFORM Interrogation Routine to Extract Request Data from ADS G402A Data Base 79

Appendix D: *BASS Program Listings* 80

Appendix E: MIC Demand Patterns 83

Appendix F: Crosstabed Demand Data for MICs MFF, MGG, MJJ . . . 86

Appendix G: Sample of DS-MIC Intransit Data 87

Appendix H: TANDEM ENFORM Interrogation Routine to Extract Intransit Data from ADS G402A. 88

Appendix I: P&A AID Program Output for Sample Intransit Data . . 89

Appendix J: Performance of MIC Stockage Policies 91

Appendix K: Results of D033-Implied VMR Test 94

Appendix L: MIC Simulation Logic Flow Charts 95

Appendix M: Demand Data Used in First MIC Simulation 97

Appendix N: SLAM II Source Listings for MIC Simulation 99

Appendix O: Definitions 109

Bibliography 115

Vita 118

<u>List of Figures</u>

Figure		Page
1.	Extract of D033 TVA Report	19
2.	Two Hypothetical Demand Distributions	21
3.	Poisson Based Demand Distributions	33
4.	MCC Demands at NSN Level	48
5.	MDD Demands at NSN Level	48
6.	MCC Demands Weighted by Units	50
7.	MDD Demands Weighted by Units	50
8.	Observed Intransit Days for DS to MIC MSS (n=137)	54
9.	Simulated Intransit Distribution (Lognormal μ=5.46, σ=3.65)	55
10.	Sample of D033 "TVA" Report	77
11.	MFF Demands at NSN Level	83
12.	MFF Demands Weighted by Units	83
13.	MGG Demands at NSN Level	84
14.	MGG Demands Weighted by Units	84
15.	MJJ Demands at NSN Level	85
16.	MJJ Demands Weighted by Units	85
17.	SLAM Model of MIC Logic--1	95
18.	SLAM Model of MIC Logic--2	96

List of Tables

Table		Page
1.	C Factor Percentages	21
2.	VMR	22
3.	D062 EOQ Demand Characteristics	30
4.	Comparative MIC Demand Statistics	51
5.	Crosstabs of MCC Demands	52
6.	Crosstabs of MDD Demands	53
7.	LIFR Performance of 30/15 MIC Stockage Policy	59
8.	Percent of MIC Requests within Implied Demand	60
9.	LIFR Performance of 7/3.5 MIC Stockage Policy	64
10.	LIFR Performance of Lot-for-Lot MIC Stockage Policy	65
11.	Comparative LIFR Results	66
12.	MIC "MXX" Performance Measures	67
13.	MIC MCC Performance Measures	68
14.	Performance of 30/15 MIC Stockage Policy	91
15.	Performance of 7/3.5 MIC Stockage Policy	92
16.	Performance of Lot-for-Lot MIC Stockage Policy	93

Abstract

Depot Maintenance makes many efforts to plan parts requirements and assure adequate stocks are available to meet demands. Nevertheless, many parts with recurring usage never seem to be adequately stocked to support actual requests. The overall direction of this research is to parallel and build upon research by the Air Force Logistics Management Center (AFLMC). AFLMC studied variability of demand at the base-level; this research investigates variability of demand for Depot Level Maintenance. The purpose of this study was threefold: 1) to determine assumptions made by the MIC and D033 stockage models in regards to demand, 2) to analyze actual Depot Maintenance parts demands and assess if these assumptions were valid, and 3) to evaluate (simulate) alternative maintenance inventory center (MIC) stockage policies.

Analysis of demands from five MICs indicated demands levied against the aircraft area MIC tended to be constant Poisson in nature. Demands for the non-aircraft areas tended to be more variable and for higher quantities. Research suggested current MIC stockage policy was not capable of providing overall 95 percent line item fill rates as presented by certain data automation reports. The D033 (O&ST) safety level equation was also examined and research indicated it did not adequately accommodate observed variance in demand.

Simulations showed the current 30/15 day (stock level/reorder point) policy is good for many expendable items. However, a simulated hybrid lot size and safety level approach can maintain similar line item fill rates and simultaneously reduce stock levels for some items. The simulated 7/3.5 day policy showed the lowest fill rates and highest backorder-days.

Depot Maintenance Parts Demand Distribution
and
Evaluation of Alternative Stockage Policies

I. Introduction

General Issue

One of the major impediments to productivity and readiness in Depot Maintenance is the lack of effective parts support (19:2;18). Depot Supply manuals and reports (D033-TVA) indicate that as an objective the supply system should accomplish 95 percent total fills for demands against parts with computed stock levels. However, fill rates to Depot Maintenance are frequently lower, and according to a HQ AFLC Maintenance working paper, over 375 million dollars worth of parts were on backorder to Depot Maintenance at the end of January 1988 (16:11-12).

Experience with low fill rates, large numbers of aging backorders and the resulting negative impacts upon production motivates maintenance personnel to create buffer stockage. This is done by ordering parts sooner than absolutely necessary and in quantities that are greater than the minimum expected needs. Although well intentioned, this ties up both Depot Maintenance funds and also repair parts that may be required by other users.

A HQ AFLC/MA letter dated 22 Dec 87 stated that the command average of days worth of material on hand in the Maintenance Inventory Centers (MICs) was over 60 days; later information suggests it may even exceed 150 days worth of material (17:4). MICs are normally authorized to stock thirty or fifteen days worth of material, depending upon the type of material, for instance, thirty

days worth for expendable items and fifteen days worth for repairable items (17:4).

When adequate parts levels are not available to meet the need of depot production shops, the resulting low fill rates and high backorders contribute to production slowdowns and stoppages. These production slowdowns and stoppages result in a build-up of inventories of other parts that are available. Specifically, some parts remain in stock (available) because the end-items they are used on are awaiting the backordered parts. These inventories of available but idle stock can be further increased if, without knowledge of the pending production stoppage, the MIC submits replenishment orders in anticipation of demand.

It can be argued low fill rates and the resulting backorders are actually symptoms of underlying problems related to parts requirements determination and inventory management. Not all parts shortages have a direct relationship to requirements determination and material management. However, any improved understanding of depot maintenance parts requirements and stockage techniques can only improve the ability of the Air Force Logis*'c Command (AFLC) to meet its mission. Further, even a modest improvement can lead to significant savings to the Air Force since 1 to 2 billion dollars a year are spent in Depot Maintenance parts usage.

Therefore, the objectives of this research effort are: 1) to investigate the Depot Maintenance parts demand environment and supply techniques, 2) to determine and evaluate some of the assumptions underlying these supply techniques, and 3) to investigate the relative performance of alternative stockage techniques.

Introduction

There are two different but complementary perspectives to the specific issue of parts demand distributions. The first perspective is more traditional and relates to AFLC's implementation of classical statistical inventory control techniques--daily demand rates, economic order quantities, safety levels, reorder points and various assumptions about constant and known rates of demand. This perspective assumes demand for one part is independent of demands for other parts--independent demand. Safety stock calculations and classical economic order quantity (EOQ) formulas are intended for the cases of independent demand (27:90).

The second perspective assumes demand for a part is dependent upon demand for another part(s)--dependent demand. This perspective recognizes that the quantity of parts demanded and the time phasing of when the parts are required is dependent upon production and lead time schedules for higher level assemblies. This approach of deriving dependent, time-phased parts requirements is generally entitled Material Requirements Planning (MRP). Note, selected definitions and terms relating to Depot Maintenance and Depot Supply are attached as an appendix.

Statistical Inventory Control Techniques. The inventory models for MICs and Depot Supply imply certain assumptions regarding characteristics of Maintenance (MA) parts demand distributions. For example, implied characteristics include the distribution of demand, its variance, and its variance-to-mean ratio. The validity of statistical assumptions and inventory models directly impacts the resulting stockage policy's ability to effectively support demands. The Depot Supply (DS) D033 stockage calculations include: 1) how much to stock (stockage objective), 2) when to reorder (reorder point),

and 3) is safety stock required. For items stocked in a MIC, certain levels of demand variability are implied if 95 percent total fills are to be accomplished with a stockage objective equal to thirty times an average daily demand rate (DDR) and a reorder point equal to fifteen times the DDR.

This research builds on an Air Force Logistic Management Center (AFLMC) study by now Lt Col Douglas Blazer (6). He studied the variability of maintenance parts demands and alternative methods to accommodate them. His study focused on base-level rather than depot-level (6).

Material Requirements Planning. Material Requirements Planning (MRP) links the planned assembly schedule with the corresponding bills of material (BOM). The BOM indicates how many of which subassemblies and components are required per end-item. The MRP system is then said to create an "explosion" of parts requirements for the scheduled "finished-goods" schedule; "...the manufacturing parts explosion and lead-time system translates the finished goods demand schedule into a plan for when and how many of each item must be in the inventory" (4:166-167). After computing the number of items required, MRP compares the quantities required by time period with the expected availability of on-hand and due-in stocks.

MRP identifies which orders to de-expedite or cancel and which materials should be transferred to other workloads. By considering schedules and lead-times, MRP time phases resupply and production orders so materials become available when and only if they are required. Thus MRP can resemble a just-in-time system as it minimizes the amount of stored, in-process, and finished goods inventories.

In theory, safety stock is contrary to the principles of MRP (20:261). MRP philosophy, however, does recognize the need for safety stock when supply is

uncertain or end-item demand is independent and variable. MRP literature also provides for stock levels to cover defective units through a planned reject allowance.

In manufacturing, given the production schedule, requirements for raw materials and components are dependent on the BOM and the schedule. This dependent relationship is served by MRP. However, even in logical MRP application areas, there are instances where it is more appropriate to use statistical-based economic order quantity (EOQ) techniques (which minimize total variable inventory costs). High volume, low value components, or raw materials, often are more economical to manage through lot-sizing (and carrying enough safety stock to prevent frequent stockouts) than to control through MRP.

In a pure manufacturing environment, parts requirements are essentially a constant and derivable function of production schedules and bills of materials. In Depot Maintenance, the nature of remanufacturing (overhaul/repair) leads to varying replacement parts demands. Different units of the same type end-item can have markedly different replacement parts requirements. Therefore, a component's replacement percentage factor may be more appropriately considered a random variable with a mean (average) and some measure of dispersion (variance) about the mean.

When variability exists in repair part replacement, it can be argued that conventional MRP logic is somewhat ineffective--the manufacturing BOM leads to excess stock as not all parts are replaced 100 percent of the time. However, using an average replacement percentage is also questionable as it will not provide enough stock in all cases. If a future time period's material requirements are based on an average, approximately 50 percent of the time

actual demands will be less than the projection. Also, approximately 50 percent of the time demands will be greater than the projection--a 50 percent service level (assuming demands are approximately normally distributed).

To some degree, a direct and derivable dependency of parts demand exists in the remanufacturing or repair environment. Thus, approximate component requirements can be estimated on the basis of an average replacement factor although consideration should also be given to the variability of demand.

This potential for random demands during remanufacturing suggests that some portion of the demands are at least approximately independent. Therefore, perhaps modified statistical inventory management techniques merit consideration.

Statement of Problem

This study examines whether the implied assumptions of Depot Maintenance demand rates and their variability are appropriate. It also investigates whether alternative means could be used to more accurately estimate the variability in demand patterns and therefore improve supply support to Depot Maintenance.

Research Questions

Specific questions to research include the following:

1. For items stocked in a MIC, what is the logic for the MIC reorder point and what demand characteristics (frequency, average size of request, and variance-to-mean ratio, VMR) are implied by a 95 percent MIC fill rate objective.

2. For items that are only stocked in Depot Supply, what is the logic in the D033 safety level model and what demand distribution parameters are implied to support an objective of 95 percent fill rate from supply stocks.

3. Are actual demand distribution characteristics significantly different from what is implied in the MIC and D033 models? What probability distributions fit the actual parts demand distributions?

4. What criteria are there for delivery intransit times from Supply to Maintenance and the MICs? Do the assumed times reflect actual intransit times?

5. What alternative inventory models for MIC and DS stockage policies exist? How does their performance compare (if simulated) to current methods?

6. Based upon the empirically-derived demand distributions and alternative safety level computation methods, what changes might be expected in the stockage performance levels and the costs to support the 1 billion dollars plus in annual parts requirements for Depot Maintenance?

Scope of Study

The overall approach is to: 1) learn as much as possible about variance in parts demand, and 2) investigate means to more effectively support parts requirements in light of demand variability.

This thesis effort gathers and analyzes data that describe the remanufacturing/repair parts demand distributions (from the perspective of the MIC or Depot Supply if the item was not stocked in a MIC). This information is then used to derive alternative methods of computing stockage levels under conditions where parts demand is taken as independent or MRP does not otherwise apply as a material purchasing or prepositioning tool.

The initial objective of this study is to better understand the demand distributions for consumable parts. Specifically those parts coded with

Expendability, Recoverability, Reparability Category (ERRC) designators XB3 or XF3. Further, the study included only those XB3 and XF3 items that are controlled and costed as direct material--material required by and directly costed to an end-item in work. Thus, the population studied included only those consumable items issued by or through a MIC directly to production and charged to an end-item.

Bench stock items are specifically not included. The frequency of requests for bench stock items from MIC or Depot Supply is highly correlated to factors beyond the interest of this study. For example, bench stock requests may be related to the frequency of bench stock reviews and individual practices of production workers, such as storing small quantities of parts in workbenches. These last two considerations would tend to distort and mask the actual demand distributions for these parts.

Further, end-item components which themselves may be repaired when they fail (ERRC XD2 and XF3) are excluded due to differences in stockage models and formulas. Similar exclusions of ERRC XD2 and XF3 items were used in the AFLMC study referenced earlier.

Chapter Two will address further background and review pertinent literature. Chapter Three will discuss collection and analysis of Maintenance demand data, implied assumptions of the stockage models, and a simulation of alternative stockage models.

Chapter Four will present the findings and analysis from the data evaluation and simulations. And Chapter Five will conclude with a summary and recommendations.

Representative examples from the data collection, simulation, and analysis processes as well statistical and simulation computer models are

provided as appendixes. AFLC Maintenance Material and Supply phrases and terms may not have the same interpretations as the same terms in other elements of the Air Force and Department of Defense. Therefore, selected definitions are attached as Appendix M.

II. Background and Review of Literature

Overview

Material support to Depot Maintenance (MA) is provided through three possible routes.

In one "route", items may be stocked by both the MIC and Depot Supply (DS). In this case the MIC issues material to production and is replenished from DS stocks as required.

In the second, parts support is provided solely by DS stocks to the production line. Items may receive this type of direct support because the nearest MIC does not stock the item for a variety of reasons, including: 1) the item may be too large to store in MIC; 2) the item usage may be too infrequent to justify MIC storage; or 3) due to the nature of the item, it may need environmental or security controls not available in the MIC.

In the third route, production line parts requirements are supported strictly by MIC stocks and there are no additional stocks in Depot Supply (DS). Such situations may include the following: locally manufactured parts which are made by and stocked solely in MA for their exclusive use in remanufacturing and repairing end-items, or they may encompass local purchase and certain shelf life items requiring environmental controls such as refrigeration systems for sealants and cryogenic fittings. Aspects of each route are discussed in the following sections.

Depot Maintenance (MIC) Stockage

The recommended MIC stockage objectives are recomputed by the Exchangeables Production System (EPS), also called the G402A system, every

seven days. The HQ AFLC Depot Maintenance guidance for MIC stockage objectives and reorder points is (3:243-244):

> MIC material will be stored in quantities sufficient to meet production requirements, but not to the extent that excesses will generate. To assist in maintaining a balanced stockage position, each item has a system computed stockage level or a manually established minimum special level and a system computed retention level.
>
> Each week, the G402A computes a MIC stock level for a MIC stockage for all NSNs [National Stock Numbers] on the MIC detail. A 30-day stockage for expense material ERRC...[XB3 or XF3], and a 15-day level for investment material...[XD2 or XD3] ERRC coded assets. MIC personnel will initiate the MIC replenishment transaction at the 50 percent level of the stockage objective, or earlier if experience indicates additional order and ship time is required.

The actual procedures used to implement this stockage policy are outlined in the next section. Stockage objectives are assumed to be solely the G402A computed values. For some items, however, special levels are used to compensate for a failure of computed stockage objectives and reorder points to consider demand variability. This research addresses the problem of demand variability.

<u>Exchangeables Production System</u>

The EPS provides enhanced management information capabilities to Depot Maintenance management and production control functions. Compared to the batch systems and inflexible data presentations provided by the DS D033 System, EPS creates a means to improve material support at less cost through better visibility and management of parts and exchangeables.

> The [EPS] G402A is an on-line, real time system used by Production Support Function (PSF), Indirect Material Function (IMF), Maintenance Inventory Center (MIC) and scheduling personnel to order/issue material...This system provides the capability to update data by processing material requirements, issues, turn-ins, and correction transactions; then to retrieve this information by means of CRT terminals and printers. This system provides visibility of MIC direct/indirect material issue/turn-ins, and production scheduling requirements, issues and turn-ins. (3:8-9)

EPS/G402A computes MIC stock levels based on an average daily demand rate (DDR) times a specified number of days (30 or 15) to suggest a stockage objective and reorder point. Also, some end-items that use part X also have bills of material with standard replacement percentages. When workload schedules and bills of material are loaded into the G402A system for these end-items, then G402A computes a stockage objective and reorder point based partially on historical DDR logic and partially on projected dependent material requirements. For the purposes of mathematical clarity and tractability, this research is restricted to the question of demand distributions and parts support where bills of material do not exist or are not used for determining stockage requirements.

The logic for the MIC stockage objectives used in G402A is given by the following excerpt from the draft manual (AFLCM 66-411) for EPS (2:23-24):

> The recommended stockage is computed in the system every seven days to determine the new 30 day requirement. This is not depot supply recommended stockage. There are several ways the system computes the recommended stockage which are explained.
>
> (1) If the NSN is not planned and has 6 months or more of issue history, the system will compute the stockage using the simple average of the last six months for the 30 day recommended stockage.
> (2) If the NSN is not planned and has less than 6 months of issue history, the system will compute the stockage using the simple average of the months available for the 30 day recommended stockage.
> (3) If the material is planned the system will use the issue history simple average times .5 plus the 30 day requirement from the end-item computation, times .5, using this for the 30 day requirement.

Beyond existing functions, the front end edit capability planned for future implementation should assist to assure that parts requests and bills of material are correct. Otherwise data may be compromised by possible production line requests for unnecessary quantities or for necessary quantities but costed against the incorrect end-item workload.

Parts request front end editing, and parallel management efforts on bills of material, will help assure validity of demand history data at the bills of material level. For the purposes of studying demand distributions at the MIC and/or D033 stock record level, the existing demand data will be taken as being adequate.

Depot Supply Stockage

The stockage policy in this section relates to ERRC designator XB3 items and also XF3 items that are not repaired as separate controllable end-items. In other words, these XF3 items are treated as consumable assets not as reparable assets. The following policies are from AFM 67-1, Vol III, Part Two (12:17-1 through 17-9):

> An important element of stock control is the establishment of the (D033) requisitioning objective [stock level]. It is mechanically computed to regulate quantities of each item to be on hand and on order at any one time. Stock levels for economic order quantity (EOQ) type items (ERRC designator XF3 and XB3) will be established after three demands have been recorded against the record.

Stock levels and reorder points are computed daily under several conditions. The conditions most germane to the research are when " Assets are...below the current reorder level...[or] the item...has not been releveled (stock level and reorder point recomputed) in the past 90 days" (12:17-1).

There are several intermediate computations that are performed by the D033 releveling routine. They are discussed in the following paragraphs, followed by explanations of the stock requisitioning objective and reorder point formulae.

Intermediate Calculations. The stock control factor (SCF) is the number of Maintenance demands (in units) accumulated since the stock level begin date (SLBD)--a cumulative total over the last 0 to 365 days. Demands are recorded

for "recurring demands" against the stock number actually requested by the user (12:17-2). Accumulated demands are reduced by the number of turn-ins of serviceable material that were initially requested and coded as recurring demands.

During releveling, D033 computes a "days (of) experience" (DE) for the item or family by subtracting the SLBD from the current date. Specifically, AFM 67-1 indicates that if the computed days' experience is less than 180 days, 180 days will be used in lieu of the actual days' experience. Or when it is determined, prior to releveling, that the days' experience is more than 365 days, the Daily Demand Rate (DDR) is used to adjust the stock level factor to represent an 180 day period (12:17-2). The DDR is the theoretical average usage of parts per day and is computed as the stock level factor (accumulated demands in units) divided by DE (days to accumulate the demands). "The computation is carried to four decimal places. Whenever the date of last demand is 366 days or older the DDR will be zero" (12:17-2).

D033 Formula. The formulas used by D033 in computing stock levels and safety levels are provided in AFM 67-1, VOL III, PART Two and the D033 Technical Support Manual and are noted as follows: (1:8-2;12:17-8 & 17-9).

The days experience (DE) of consumption for the item is:

$$DE = \max[(\text{current date} - SLBD), 180] \tag{1}$$

where SLBD (stock level begin date) represents the date of the oldest request on record for the item. If it is determined prior to releveling that the DE is greater than 365, the DE is factored and reduced to a maximum of 180 days. The factoring involves recomputation of the DDR and multiplying by 30 to obtain 30-day adjustments (1:8-2); the SLBD is similarly adjusted if DE is greater than 365. The pipeline time (PLT) for resupply is:

$$PLT = \text{total days} / \text{total items [for days on record]} \quad (2)$$

The safety level quantity (SLQ) is:

$$SLQ = [(\#demands/DE)*(DDR*PLT)*(SCF/\#demands)^2]^{1/2} \quad (3)$$

where SCF equals the number of units requested over the last number of days corresponding to DE. The order and ship time quantity (OSTQ) to support average demand during resupply is:

$$OSTQ = DDR * PLT \quad (4)$$

The economic order quantity (EOQ) is:

$$EOQ = [Y * (365 * UC * DDR)^{1/2}] / UC \quad (5)$$

where Y equals 16.31 for local purchase items or 8.33 for all other items, and UC equals unit cost. The stock level (SL) is:

$$SL = SLQ + OSTQ + EOQ \quad (6)$$

And the reorder level (ROL) is:

$$ROL = SLQ * OSTQ \quad (7)$$

where the D033 Technical Support Manual (TSM) indicates the following overriding assignment (1:8-3),

ROL = greater of: 1/2 computed stock level or
1/2 maintenance projected requirement or
1/2 minimum special level or
SLQ + OSTQ

Stock Computations. Depot Supply stocks of ERRC designator XB3 and XF3 items are replenished when the asset position is equal to or less than the computed reorder level (ROL). The requisition quantity is computed in two steps at this point. First, D033 establishes the current asset position by adding together the appropriate on-hand, due-in, and any supply point balances (12:17-4). Then D033 subtracts the current asset position from the

stockage objective (computed stock level). The difference is the basis for the stock requisition.

Further, note that the potentially overriding factors are subject to modification due to funds suppression and other management techniques. The actual stockage objectives used and quantities requisitioned (when a requisition is created) are subject to several influencing factors. Stock replenishment funds control can be applied (by DS) wherein stock replenishment can be suppressed. DS inventory manager review codes can also cause differences between computed replenishments and actual requisitions. Finally, MISTR (Management of Items Subject to Repair) projections can also impact actual stockage levels.

Workload Projections. The D033 system also has a capability to stock material based on parts projections. These forecasts of parts requirements result from several systems that combine (logically) with D033 to form what is commonly known in AFLC as "the MISTR drive"--Management of Items Subject to Repair (MISTR) Requirements Scheduling and Analysis System (G019C). MISTR/G019C is the system used to mechanically transmit negotiated workload requirements to MA management. Together these systems resemble an open-loop, elementary, Material Requirements Planning system.

Basically, depot overhaul end-item workload requirements for upcoming weeks and quarter(s) are negotiated between MA and item managers in the Material Management Directorate (MM). These negotiated workload quantities are input to MM's workload management system (D073), which in turn passes workload requirements by end-item and time frame to MISTR/G019C. The G019C system further refines the scheduling and management of customer-driven and MA driven repair requirements.

The G019C system passes time-phased workload requirements to the Depot Maintenance Material Support System (G005M) which in-turn explodes its bills of material (BOMs) into parts requirements by end-item, time frame, and supporting MIC. Simplistically, expected parts requirements for a bill of material/end-item are approximated by multiplying the parts replacement percentage times the units (of the component) per assembly times the workload requirement, for each time frame. These parts requirements for each NSN are accumulated across all end-item workloads (by MIC, by time frame) and passed to the D033 system. These accumulated requirements are referred to as maintenance projected requirements (MPR) (19;12:17-4).

Due to factors such as funds availability or an DS inventory managers' experience with an item, D033 can be directed to factor stockage objective and reorder points. The MPR-based stockage objective can be suppressed (from entirely to not at all) by DS, or the resulting suggested replenishment actions can be suppressed or excepted out for manager review (on the basis of funds availability, cost of order) (12:17-5).

The D033 system's ability to conceptually accept parts projections and proactively order parts ahead of actual shop requests is in contrast to historical based systems that naively forecast and purchase parts for future requirements based on past usage. This proactive capability is particularly useful in providing parts support to new or increasing workloads.

The D033 system can also use the out-year (13 to 24 months) parts requirements to determine parts retention levels even when there have been no actual demands in the last 366 days and the DDR has dropped to zero (12:17-4). This is beneficial in supporting low density workloads in MA where repair

actions are required infrequently and thus demands are too infrequent for otherwise computing a stock level.

Unfortunately, the MISTR drive parts projections are frequently suppressed through inventory manager actions. As a result the stockage objectives are based largely upon demand history, whether it accurately reflects future workloads or not. This research proposes that low fill rates and high backorder levels result if the workload changes from quarter-to-quarter, or if demand is not independent, constant or otherwise meet the assumptions for an EOQ-based system. D033 resembles an EOQ order quantity and reorder point system when projected Maintenance demands are not fully used to compute stock levels.

Even under all but total funds suppression, the reorder level is set at some value. The ability of that reorder level to support demands at a prescribed fill rate depends on the expected variability of demand. As will be discussed in a later section, the Standard Base Supply System (SBSS/D002A) was reported to assume a parts demand variance-to-mean ratio of 3:1 (6:12). The various DS policy, procedure and D033 system manuals reviewed did not indicate explicitly an expected amount of variability in Maintenance demands. Discussions with several AFLC supply policy personnel regarding the level of variability D033 is designed to accommodate provided no known expected level of demand variance.

Therefore, the research proposes to devise a method based on simulation to estimate what range of variability is expected by D033 to achieve certain overall fill rates. It was desired to minimize assumptions regarding the shape of the demand distribution. The deterministic methods available required such constraining assumptions. This will be discussed further in Chapter Three.

Air Force base-level activities normally use the SBSS/D002A for parts support. The SBSS also uses EOQ in its consumables stock level computations. The applicability of demand variance assumptions (including the 3:1 variance-to-mean ratio) has also been questioned for the SBSS system. Research into base-level demand variability provides insight to this depot-level research. The next section provides clarification on the MIC and D033 fill rate objectives.

MIC and DS Fill Rate Objectives

The D033 TVA Report ("Depot Maintenance Material Support") states objectives for MIC and D033 support to MA requests. A sample copy of the report is provided in Appendix A and an excerpt of the pertinent section is provided in Figure 1. As shown in Figure 1, there is an objective for the percent of NSNs requested to match against NSNs with MIC stock levels; there is also an objective for percent of matched requests to receive total fills.

	NUMBER DEMANDS	NUMBER MATCHED	% MATCH	% MATCH OBJ	NUMBER TOTAL FILL	% TOTAL FILL	% TOTAL FILL OBJ
MIC	205	171	83.4%	85%	132	77.1%	95%
DS	74	41	55.4%	85%	41	100.0%	95%

Figure 1. Extract of D033 TVA Report

As stated by the sample report, 205 requests (within the month) were levied against the MIC. The MIC had computed or special levels for 171 of the NSNs requested--171 of the requests matched stock records. The report shows a "match" objective of 85 percent. Of the 171 requests with "matching" stock records, the MIC was able to fill 77.1 percent of the requests. The report shows a fill rate objective of 95 percent. Note that the 95 percent objective is for a

line item fill rate, not a unit level fill rate. The line item fill rate represents the percent of requests that were totally filled. A unit fill rate would represent the total percentage of units requested that were filled. For example, if a request for ten units is issued six units and the other four units are backordered, the line item fill rate is zero and the unit fill rate is 60 percent.

The report states equal match and (line item) fill rate objectives for the MIC(s) and D033--85 percent for matches of requests to stock records and 95 percent for fill rates. Given the above background on MICs and D033, a review of research literature follows.

Review of Literature

To a large degree, the focus for this research on depot-level demand variability parallels an article written by then Major, Douglas Blazer at the Air Force Logistics Management Center (AFLMC) (6). The research undertaken by AFLMC focused on base-level, not depot-level demands. Its analysis and recommendations were specifically tailored to the SBSS. Major Blazer's article and other pertinent articles are reviewed next.

Blazer. In a Spring 1985 article in the Air Force Journal of Logistics, Major Blazer described efforts being undertaken by AFLMC to take a top-down look at current Air Force inventory models and challenge their assumptions. The article specifically challenges the SBSS's assumption on demand variability (6:11-13+).

He explains the SBSS demand level is made up of a stockage level and a reorder point. The formula for the stockage level is as follows (6:11):

$$\text{Stockage Level} = (Y/\text{Unit Price}) * [(DDR * 365 * \text{unit price})^{1/2}] \quad (8)$$

where Y = 8.3 for nonlocal purchase items, or Y = 16.3 for local purchase items.

The SBSS reorder point is presented as "the amount of stock necessary to support demand during the replenishment cycle" (6:11). The reorder point consists of the order and shipping time quantity (O&STQ) and the safety level quantity (SLQ). "The O&STQ is the amount of stock necessary to support demand during an average lead time. The SLQ is an estimate of the standard deviation of demand during the order and ship time (O&ST)" (6:11). The formula for O&STQ and SLQ follow, respectively (6:11):

$$\text{O\&STQ} = \text{DDR} * \text{Average order and Shipping Time} \tag{9}$$

$$\text{SLQ} = [3 * (\text{O\&STQ})]^{1/2} \tag{10}$$

> The safety level is multiplied by a C factor, which is used to set the percentage of time a customer order should be filled during the replenishment cycle. The percentages are...(in Table 1): (6:11)

Table 1: C Factor Percentages

C Factor	Percentage
1	84
2	97
3	99

Essentially, the C factor concept equates to the use of standard deviations in a Standard Normal statistical table, wherein the mean plus one standard deviation covers approximately 84 percent of the area under a Standard Normal curve.

The AFLMC study indicated that the current SBSS assumes a variance-to-mean ratio (VMR) of 3:1 (or simply 3). The 3:1 VMR was also noted by Dr. J. Patterson in a 1980 study. Figure 2 is an adaptation from Blazer (6:11); it illustrates the notion of variance and VMR.

The figure represents two hypothetical demand distributions. The curves depict the probability density functions of two distributions of demand over some period of time, such as 30 days. While the average of each

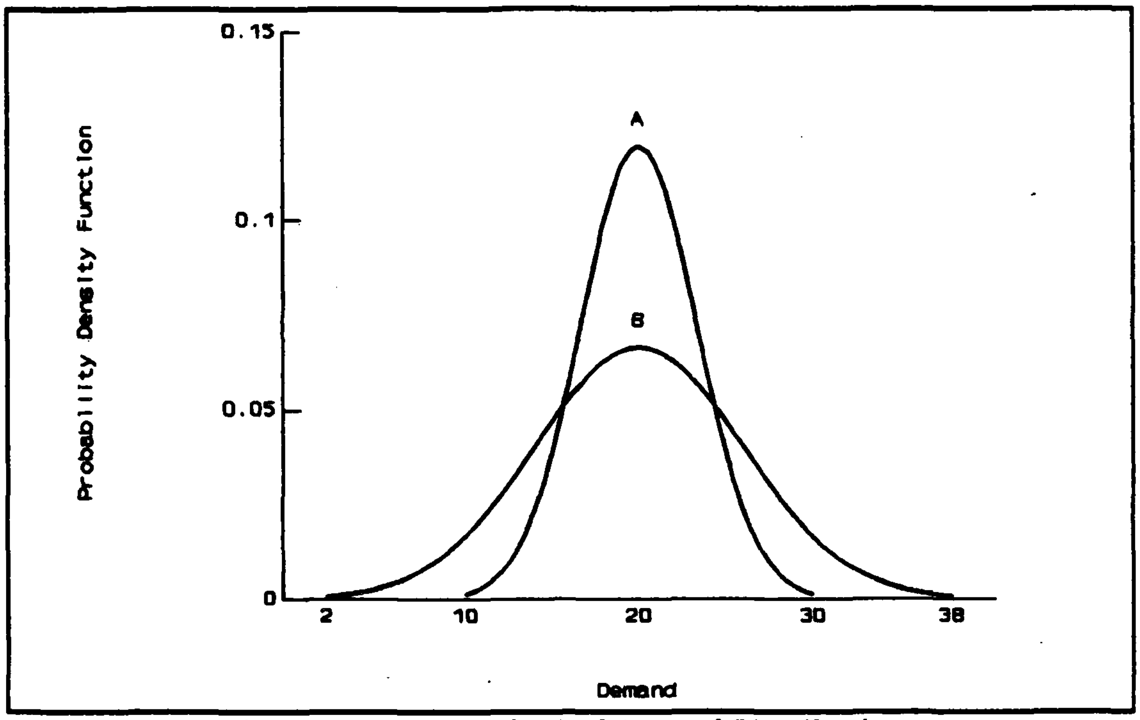

Figure 2. Two Hypothetical Demand Distributions

distribution is equal to 20, the variances, shapes and VMRs are different. In other words, if the reorder point was set assuming demand distribution A and in fact distribution B was the case, the average fill rates would certainly be less than 84 percent.

The article explained the AFLMC examined the average VMR for EOQ items at five Air Force bases and found the values shown in Table 2.

Table 2: VMR (6:12)

Base	Average VMR
Upper Heyford	14.2
Kunsan	27.6
Little Rock	21.7
Randolph	30.2
England	29.5

Blazer concluded "The current system does not accurately measure demand variability which results in ineffective stockage for over 40% of [Air Force] (SBSS) consumable items" (6:12).

Further, the article points out that the SBSS stockage formula assumed a fixed O&ST, even though O&ST can also vary and result in stockouts. Blazer's main points were that a means was necessary to accurately measure variability in both demand and O&ST, and that the safety level quantity needs to be based on realistic variability estimates, not inappropriate assumptions. The study also examined individual NSN VMRs and concluded a ceiling should be used on any SLQ derived for any NSNs with exceptionally large VMRs.

Blazer's study evaluated six different methods of forecasting demand variability for use in computing base-level stockage levels. Simulating the operation of an SBSS, the six forecasting methods were compared using four different inventory performance measures: 1) fill rate (what percent of demands were filled from stock), 2) on-hand inventory, 3) rates for MICAP (roughly, not mission capable due to lack of parts) and 4) "efficiency" as percent change in fill rate or MICAP rate as a percent change in inventory level. The best overall forecast method accounted for variance of demand and order and shipping time with a ceiling on the safety level. The article recommends demand variance and safety level be computed by (6:13):

$$\text{Variance of Demand} = \frac{\Sigma\,\text{Demand}^2 - \dfrac{[\Sigma\,\text{Demand}]^2}{n}}{n} \qquad (11)$$

where,

Σ Demand = cumulative recurring demands,
Σ Demand² = the sum of the demands squared, and
n = number of days since date of first demand.

$$\text{Safety Level} = C * (\text{O\&ST} * \text{variance of demand} + \text{DDR}^2 * \text{variance of O\&ST})^{1/2} \qquad (12)$$

where C is the assigned C factor.

The article indicates the recommendation was implemented worldwide in the SBSS, resulting "in an average 14% increase in worldwide fill rates for consumable items and a reduction of over 20,000 grounding incidents a year" (6:22).

Blazer simulated base-level demands using parameters based on actual demands and applied them to a compound Poisson process known as constant-Poisson. As Van Landingham and Shariq noted, a large variety of practical problems can be described as compound Poisson processes (28:50). The following subsections will discuss the specific aspects of various compound processes as a means to simulate parts demands.

RAND--Sherbrooke. Craig Sherbrooke reviewed analytic and application aspects of discrete compound Poisson processes in a memorandum for the RAND Corporation (25). In it, discussions include the geometric and logarithmic processes within the family of compound Poisson distributions.

Regarding compound Poisson processes, Sherbrooke indicated, "they enable the analyst to model more complicated systems while retaining important properties that simplify analysis (25:1). Further, the compound Poisson processes were stated to be applicable to system modelers that needed "a stochastic process which is richer than the (standard) Poisson" (25:iii).

The document was in support of ongoing RAND efforts on Air Force base-level stockage policy for recoverable items. Sherbrooke indicated the report was related to efforts to improve computational feasibility of the ongoing research through replacement of the logarithmic process with geometric Poisson. He indicated that the geometric Poisson was "particularly convenient when the analyst is interested in a simple model for time between events--as

in simulation" (25:v). The geometric Poisson process was stated to be convenient in that it requires only one probability distribution, whereas other compound Poisson distributions require two. The report also indicates, however, the variance to mean ratio of the geometric Poisson process is in the 1:1 to 2:1 range when the process is used in a multi-echelon inventory model such as base-depot. As mentioned earlier in this document, Blazer has since indicated that VMRs for many base-level items are above the one to two range.

In describing a compound Poisson process, Sherbrooke stated the following for purposes of visualization:

> Suppose customers arrive according to a Poisson process, (such that), the probability distribution of time between customers is exponential. Each customer can demand a positive discrete amount w which is independently and identically distributed as f_w. Then the demands are said to follow a compound Poisson process. (25:4)

In relation to simulation problems, Sherbrooke points out "...any compound Poisson process can be simulated with two probability distributions --an exponential distribution for the time between batches and the compounding distribution for the number of demands in the batch" (25:10). Further, Sherbrooke depicts a compound Poisson process where the compounding process is itself Poisson. For this distribution, the probability of x demands in a time interval t was given as (25:15)

$$P(x) = \sum_{y=0}^{\infty} \frac{(\lambda t)^y e^{-\lambda t}}{y!} \frac{(y\mu)^x e^{-y\mu}}{x!} \qquad \begin{matrix} x = 0,1,2... \\ \lambda,\mu > 0 \end{matrix} \qquad (13)$$

where y is the potential number of customers, λ is the mean customer arrival rate, and μ is the mean rate of units demanded (25:4,15).

Performance measuring of inventory models was discussed by Sherbrooke in another source. According to Christensen and Ewan, Sherbrooke reviewed

inventory performance criteria and concluded that " backorder criteria [seemed] to be the most reasonable because the expected number of backorders provides good results with respect to other criteria, which is not conversely true" (9:18).

<u>RAND--Brown</u>. Brown studied spare parts demand distributions for B-47, B-50, F-86, and KC-97,aircraft. While these aircraft are obviously not the prime aircraft today, some of the study's findings are still germane to this research effort.

Brown noted "...entirely different logistics policies may be appropriate for fast-moving and slow-moving parts" (7:11). The report indicated "...that the vast majority of parts are demanded very infrequently, that the demands which occur are very erratic and that most parts are also inexpensive" (7:11). The findings presented an ironic situation. Most of the spare part units demanded were for the few parts that have high demand. Most (nine out of ten) incidences of aircraft out of commission for parts occurring at March and MacDill Air Force Bases (during a two month test period in 1953) were for low demand parts, and about half of those parts did not have a demand the previous year (7:13).

These findings would support the notion that stock range and depth can be very different for stockage policies oriented to minimizing stockage cost versus supporting the flying and readiness mission. Stockage policies oriented to minimizing stockage costs (and increasing turnover) would tend to do so at the expense of stockage range, and to some extent stock depth. Whereas policies oriented to mission and part supportability would tend to increase stock range, perhaps to include items that may not have a demand within a given year. Brown noted:

> [parts demand] does not appear as a smooth and even flow over time. [and] The function of the logistics system is to contend with these

> demands so that total effectiveness of the system is made as great as possible within the budget limitations. (7:21)

Part of the research reported by Brown included demand analysis of B-47 airframe parts demanded at MacDill Air Force Base over a 15-month period. Out of the more than 1800 airframe parts demanded, there were only 258 items that registered ten or more requests. Using the ten or more requests as a minimum required for analysis, 100 were selected for more detailed investigation. Brown reported that the demand patterns for the 100 parts could be categorized into the following four groups (7:29-30):

"Group A comprised parts that seemed to be demanded in single units" (7:29). The Poisson distribution was found to fit satisfactorily using the mean demand per week. Of the 100 items selected, about 70 appeared to belong to this category.

"Group B consisted of parts for which demand occurred in multiple units per aircraft. Frequently the multiple unit was [six]" (7:29). The Poisson distribution fit the observed data when it was modified to account for multiple units, such as thinking of six units "as constituting a demand of 1 unit, 12 units a demand as 2 units, [etcetera]" (7:29). About 9 of the 100 items showed this demand pattern.

"Group C have a demand characteristic that might have been generated by a scheduled maintenance policy...the Poisson distribution did not fit the data well [for these items]" (7:29). Five of the 100 items were attributed to this category.

> Group D (like Group C) consisted of parts for which the Poisson distribution did not fit...the variance was eight or ten times as much as the mean demand. Some other probability distribution, permitting a significant difference between mean and variance, would have to be used to describe this pattern. (7:30)

Sixteen of the 100 parts appeared to belong to this category. The report noted the following:

> About 85 percent of the more than 1800 parts for which there was demand at MacDill has such low demands that it was impossible to judge their probability distribution. But the exact form of the probability distribution does not affect appreciably stockage policy for these parts.
>
> Of the remaining 15 percent of the parts, the majority...seemed to have demand patterns over time that can be described by the Poisson distribution. For these parts, statistical demand analysis has something to contribute to stockage policy.
>
> For the smaller part of the 15 percent [categories C and D], demand prediction would have to rely on probability distributions other than the Poisson--perhaps on empirical distributions observed in the past, or in some cases, on information regarding scheduled maintenance work [dependent demand]. (7:30)

Brown summarized the findings by stating that "a substantial fraction of the dollar value of issues of airframe parts pertain to items for which demand can be estimated with the help of Poisson distributions" (7:31).

RAND--Brown and Geisler. B-47 airframe parts demand at March Air Force Base was studied by Brown and Geisler. During the time frame under study (23 March to 26 September 1953), only 12 items of the 470 with demands had a sufficient number of days with demand for adequate statistical evaluation of the demand pattern (8:ii). However, of the 12 items, the demand "agrees fairly satisfactorily with the Poisson distribution if the daily data are grouped into two and three day periods"

The study suggested that "...the opportunity for demand occurs every m days, rather than every day" (8:5). This assumption lead to the following two parameter frequency distribution for daily demand (8:6):

$$p(x = 0) = \frac{m - 1}{m} + \frac{e^{-m\lambda}}{m} \qquad (14)$$

$$p(x = 1,2,\ldots) = \frac{1}{m} \cdot \frac{e^{-m\lambda} \cdot (m\lambda)^x}{x!} \qquad (15)$$

where m is the number of days in the each cycle and λ (Lambda) is the mean demand per day at the base for a given item.

Crowe and Lowman. An AFIT masters thesis by Capt Lowell R. Crowe and Levi D. Lowman, entitled An Analysis of the Exponential Function as the Underlying Distribution for Describing Failures in Inertial Measurement Units (AFIT/LSSR 22-77A) (10). In this document, the researchers concluded that the exponential distribution was not the appropriate failure distribution for Inertia Measurement Units; specifically for FLIP and LN-15 units, gamma provided the fit, and for the KT-73 unit, four failure distributions proved to be better fits than the exponential model. This has relevance because (as their thesis indicated) other studies have presumed the failures were Poisson distributed (with exponential failure rates). Their study did not indicate if a compound Poisson distribution was tested.

RAND--Hodges. In a RAND Note, Hodges "examines the model for part failures used in The RAND Corporation Supply System model Dyna-METRIC" (15:v). As Blazer had determined that the prior SBSS safety level model did not allow for actual levels of VMR, Hodges' investigation of VMR "...indicate[s] strongly that Dyna-METRIC's current probability model does not permit enough variability to credibly explain the Air Force data" (15:v).

Hodges concludes that "a model that allows more variability, such as a negative binomial model, would be more appropriate" (15:34). Hodges also notes that "the negative binomial is a 'compound Poisson' distribution in both senses in which the term is commonly used" (15:4). Those two senses being the

probabilistic distribution of the number of demands X, in a time period, and the conditional distribution of the mean μ, of X (15:4-5).

Also of note is Hodges' following observation:

> There has been some investigation indicating that, for real aircraft failure data, the variance-to-mean ratio increases with the mean, which is not a property of the negative binomial although it is a property of other compound Poisson distributions [15:6].

Shields. In a paper by Matthew Shields, he reports that a study, known as Project EOQ, was performed around 1974 by a team of Air Force Academy students and four instructors. The team's efforts were initially focused on price discounts for non-reparable items. However it later developed into a study of the entire "EOQ system" [Automatic Data System D062] (26:15-16). The D062 system is a higher echelon inventory system than the D033 in that it supports worldwide Air Force base-level consumable parts requests, not just the co-located Depot Maintenance organization. The Project EOQ team's analysis of 9767 [D062/EOQ] line items disclosed the following demand characteristics (26:20):

Table 3: D062 EOQ Demand Characteristics
As Noted by Project EOQ (26:10)

Characteristic	Percent of Inventory
Low Demand (less than 3 quarters of positive demand in 8)	44
Erratic Demand (at least 3 quarters of positive demand but with a standard deviation greater than average demand)	21
Normal Demand	35

While demands for D062 can originate from many more sources than MA or D033, the data in Table 3 does suggest some nature of the potential variability experienced by at least the D062 items used by MA.

At this point it is important to reiterate the commonality of the research literature reviewed. The MIC and D033 reorder points are greater than zero to accommodate for demand during order and ship time from the next higher level of supply. The D033 specifically provides for a safety level computation. The MIC reorder point computation is more simplistic, being based on a given number of days (usually fifteen) times the DDR. Both reorder points would seem to imply an expected variability of demand during order and ship time if they are to meet the objective 95 percent fill rate.

The literature reviewed has consistently shown that actual variability encountered in the SBSS environment has been higher than it was previously believed. Similarly, the literature has shown that actual demands have been more variable than provided for in the simple Poisson distribution and that some sort of compound Poisson process would be more appropriate. Chapter Three presents the methodology of how this research examined 1) actual demand variability, 2) the ability of the current stockage models to accommodate actual variability, and 3) the relative performance of alternative stockage models in light of actual demand variability.

III. Methodology

Overall Approach

Overall, a combination of methods was employed to investigate the research questions. Literature reviews, personal interviews, simulation and empirical methods contributed to the process. There are three major aspects to the research with regards to experimental design--1) analysis of actual demand distribution characteristics, 2) derivation of implied demand distribution characteristics (such as, demand variance, VMR, average number of days between demands, average size of request), and 3) simulation of alternative stockage models and policies.

Data Analysis

Data analysis covers two areas--actual demands and MIC intransits. Gaining new knowledge about actual Depot Maintenance demand distributions is a primary objective of this research. Gaining insight to intransit times from DS to MA was a necessity for simulation of alternative MIC stockage policies. However, it also turned out to raise additional questions for potential follow-on research, which will be discussed in Chapter Five. The methods used to analyze actual demands and MIC intransits will be presented in the following sub-sections.

Analysis of Actual Demands. The discussions on demand analysis methodology are divided into sections on distribution parameters, variables, data collection, data transformation, and actual analysis. The next section, on distribution parameters, will present the intended interpretation of selected

terms and concepts that will be used throughout the remainder of this document.

Distribution Parameters. The chapter on background and review of literature has introduced several distribution concepts and related terms. Figure 3 illustrates three of the distribution concepts and some of the terms referenced in this document.

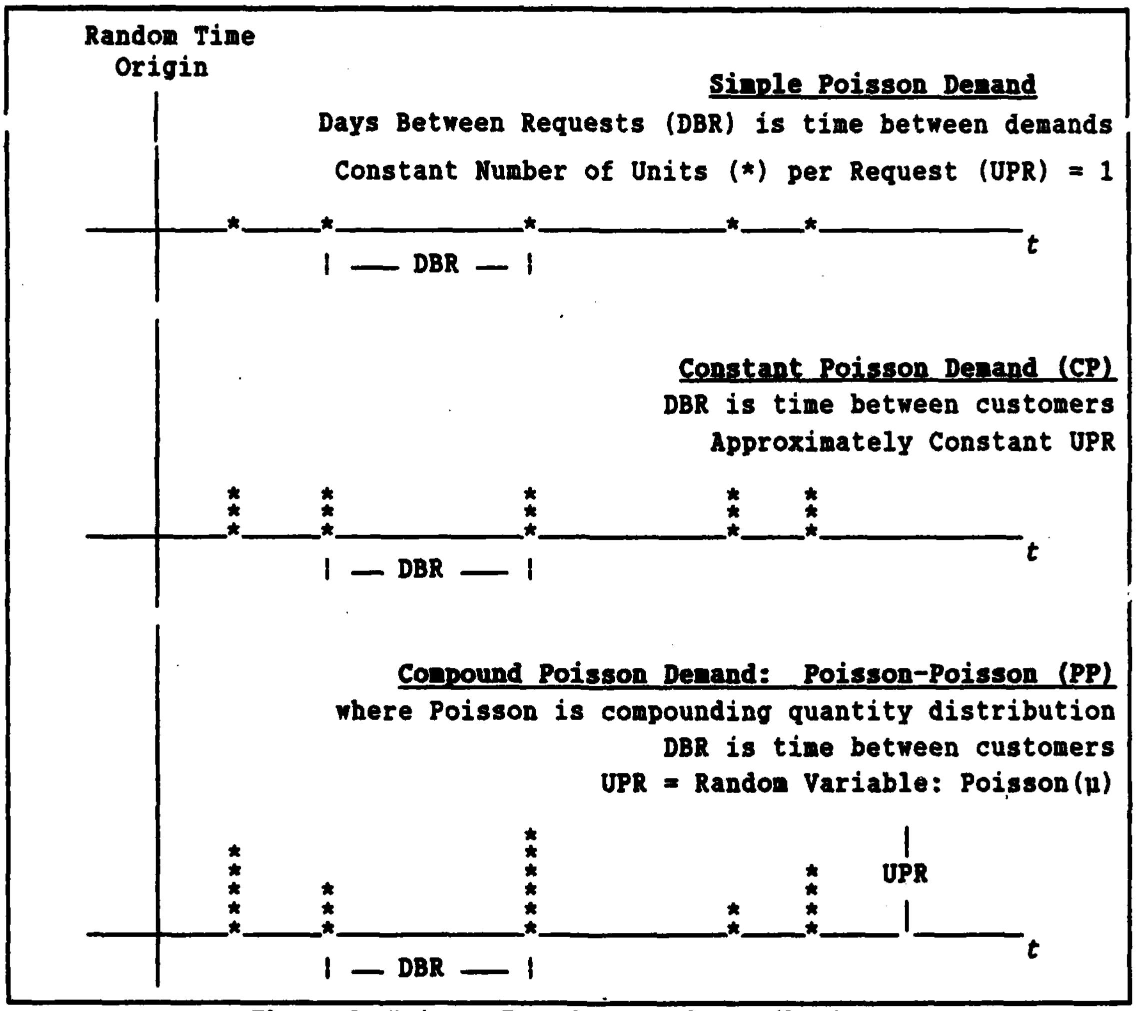

Figure 3. Poisson Based Demand Distributions

The top graph in Figure 3 represents demands that occur according to a simple Poisson process. The number of demands occurring in a fixed length of time is randomly distributed according to a Poisson process. In the simple

Poisson demand distribution, the number of units per request (UPR) is one. The average number of days between requests will be represented in this document by the symbol DBR.

The middle graph in Figure 3 represents a constant Poisson process. The requests are distributed according to a Poisson process as was simple Poisson demand, except the UPR is now equal to some constant quantity, not necessarily the quantity one. The DBR also now represents the average days between customers rather than demands for a single unit. This was the distribution used by AFLMC in their study of SBSS (5). It was also stated by the AFLMC report that this distribution "describes demand reasonably well for items where the variance of units ordered is small" (5:17). This distribution will be referred to as "CP" (constant Poisson) in the remainder of this document.

The third graph in Figure 3 illustrates an hypothetical demand pattern distributed as a compound Poisson process where the compounding quantity distribution is also Poisson. Since both the number of requests per time unit and the UPR are distributed according to Poisson processes, this distribution will be referred to as "PP" (Poisson-Poisson) in the remainder of this document.

For an item distributed according to a constant Poisson (CP) process, zero or "small" variance of the actual quantity of units (demanded) per request (UPR) is expected. Larger variances of UPR (from request to request) are expected for items distributed according to a Poisson-Poisson process. In later sections, the average and variance of items' UPR will be discussed. The logical follow-on to the statistical notions of average and variance is variance-to-mean ratio. However, VMR has already been defined to represent the variance to mean ratio of the daily demand rate (VMR of DDR, or simply VMR). To provide

clarity, the variance-to-mean ratio of UPR will be referred to as VMR_UPR in this document.

Variables for Analysis. An investigation into the relationship between VMR and fill rates requires data on average demand (DDR) and variance of demand. To compute DDR and variance, data on the individual requests is required. Therefore, within the MA parts request history maintained on G402A, the data base fields of quantity requested and date of request are the prime requirements. The NSN of the item requested and the MIC identifier of the requestor are also required to organize and stratify the extracted data.

To evaluate the simulated performance of the alternative stockage policies (models), certain derived variables (performance measures) were computed. These variables included fill rates at the unit and line item level, expected backorders (number, and duration as in backorder-days), and average level of MIC on-hand inventory associated with the particular model.

Data Collection. The focus of the MA request history was on ERRC XF3 and XB3 consumable items that are controlled and charged as direct material to production. The approach was to collect a census of demand data from five MICs at OO-ALC. The Systems Laboratory (OO-ALC/MAO) created the ENFORM program and transferred the request data to MS-DOS compatible floppy disk.

The request data collected represented 110 calendar days worth of transactions. The data consisted of MA production shop demand data processed by the G402A at OO-ALC. The ENFORM data base interrogation language was used to retrieve the required data (including NSN, date of request, quantity,

requesting organization). A sample of the collected data and a source code listing of the interrogation program are given in Appendixes B and C.

The MICs chosen for data collection are those that represent a broad cross section of types of end-item workloads. The selection was made after consulting with a systems analyst at the OO-ALC/MAO that has extensive experience with the MICs and product divisions at OO-ALC (24).

The objective was to select MICs that support one or more of the following repair/remanufacturing areas: aircraft, landing gear, missiles, black boxes/electronics, MISTR exchangeables, and training equipment or other sporadic workloads. These workloads and supporting MICs were chosen as representative of most of the demand environments encountered across AFLC Depot Maintenance. Ogden ALC does not have a jet propulsion division as do San Antonio and Oklahoma City ALCs. However it was speculated that the Ogden's landing gear function might exhibit similar characteristics--repetitive demand in a remanufacture environment with highly complex items. MICs were avoided if they were largely in support of a F-16 exchangeable workload scheduled under the (RAND) CLOUT project.

Data Transformation. The request data required editing before analysis. Most MA parts requests contain a 2C advice code. This code is commonly called "fill or kill" (the request). The distinction is that if the request is for more parts than what is on the MIC record as available, then the request is "killed" and the requestor is notified for follow-on action. If the MIC has the quantity requested, then the request is filled. The net effect is that if the part(s) is available, then the normal request priority is used; and if the part is not immediately available, then the priority denoting the appropriate level of urgency and mission impact for the backorder can be placed on the

requisition to DS. What may be a low priority when dealing with an item in stock at the MIC may be a high priority when the item must be shipped from DS or off-base. By killing the request (with the low priority) before it goes to D033, file maintenance and priority upgrade transactions can be avoided. However, this complicated the transaction history file.

Based on investigation by Wayne Rives, an OO-ALC/MAO systems analyst, the following algorithm was used to edit the data for "duplicate" transactions caused by "fill or kill" codes (24): if an NSN had two requests on the same date, for the same quantity, for the same production number, but one had a "2C" advice code and the other didn't, ignore the one with the "2C" advice code. The editing was important to avoid overstating the demand data.

Any other data transformation consisted primarily of sorting, aligning, and preparing text files for statistical programs.

Demand Data Analysis. Request data was collected for five MICs--MCC (aircraft), MDD ("black boxes" for aircraft and missiles), MGG (test equipment repair), MFF (landing gear), and MJJ (training equipment). Due to the volume of the transactions for the aircraft MIC MCC (over 21,700 requests) a random sample of 400 NSNs was extracted from the data. According to "A Guide for the Development of the Attitude and Opinion Survey" a sample size of 400 (NSNs) should achieve a 95% confidence level (11:11-14). The next largest volume of requests (approximately 7200) for the 110 days was MIC MDD ("black boxes"), so a census approach was used for this MIC and the remaining three MICs. The analysis approach was to create a program using a computer based statistical package.

From the data analyzed for each MIC, a distribution profile of means (DDR), variances, and VMR are compiled for each MIC. The variables of mean

quantity demanded per request, average days between requests, and VMR were categorized by group. Mean quantity demanded per request was computed as total number of units requested (for an NSN) divided by the number of requests for that NSN within the 110 days observed. The average days between requests equaled the number of requests divided by 110 days. Distribution cross-tabs were created for the categorized variables of average days between requests, mean number of units requested per request, and VMR.

It was noted in the literature review that a number of options were available to represent a compound Poisson process. Sherbrooke analytically described logarithmic and geometric (compound) Poisson, but noted geometric was appealing for simulation as it only required one parameter. Blazer used a constant Poisson process in the AFLMC simulation. The constant Poisson used a constant lot size (request quantity) for demands and it was stated as being a good approximation when variance was small. However it would seem that the constant lot size constraint was not always appropriate for all the demand patterns in this study. Sherbrooke also mentioned the "compound Poisson process where the compounding distribution is also Poisson with mean rate μ" (25:15). Actual demands could be analyzed from the perspective of mean requests per day and mean units per request; these could in-turn provide input parameters for a simulation. The SLAM II simulation language has a Poisson random generator; and simulation of constant Poisson or compound-Poisson demand would be technically feasible. Therefore, the data was also analyzed and categorized from the perspectives of constant Poisson (CP) and compound-Poisson demand where the compounding function was also Poisson. Note, for the remainder of this document compound-Poisson will be used to denote where the

compounding distribution is also Poisson; this distribution will be referred to as Poisson–Poisson (PP).

<u>MIC Intransit Days</u>. Although not the primary focus of this research, some understanding must be gained of the time taken for MIC intransits to be gathered from DS, transported to the MA area, processed through DS/MA receipt certification and added to the MIC balance. The functioning of a MIC inventory model must make some assumption of the intransit times. Therefore, a brief investigation into actual intransit times was made to gather data on which to base simulated intransit times.

The D033 system transmits a notification to G402A when it sends a request to the appropriate warehouse for the picking and shipment of a part to MA. At the same time an entry is added to the D033 suspense file for the intransit item. When the MIC receives the part, it sends a notification back to D033 that clears the intransit suspense. The G402A captures an image in its database of both the stock release notification from D033 and the response back from the MIC to clear the suspense. AFM 67–1, Vol III, Part Two, indicates delivery from DS to MA for routine MIC replenishments should be completed ASAP but not later than 12 to 24 working hours (12:21–12). At eight working hours per day, 24 working hours could equate to 3 days, or 5 days accounting for weekends.

Actual intransit data was collected for the thirty days during June 1988. The database was interrogated by an ENFORM program and a file was constructed of all the intransit related transactions. The data provided included dates and times of the transaction. The intransit times were calculated at the level of days and hours. Sample data and a source code listing of the ENFORM program are given in Appendixes G and H. The ENFORM program was

constructed by the MA Systems Laboratory located at Ogden Air Logistics Center (OO-ALC).

Determining Current Statistical Assumptions

The evaluation of current statistical assumptions was investigated separately by 1) assumptions relating to demand against MIC stocks, and 2) VMR of demand against D033 stocks when demands are supported directly by D033 without intervening MIC stocks.

Determining MIC Demand Assumptions. A common theme of the research literature reviewed was that stockage model performance was at least partially a function of its ability to predict or support demand variance, specifically VMR. Logically, this suggested correlation of demand VMR and model performance could also apply to the G402A MIC stockage and reorder point models. There is, however, one notable difference between the MIC reorder point equations and the more statistically oriented safety and reorder point equations of the SBSS and D033. As presented in the literature review, the MIC reorder point is oriented to days: 15 * DDR. The safety level equations of the SBSS and D033 also include adjustments for variable demand and O&ST. Therefore analyzing the assumptions in MIC demand requires investigating the correlation between VMR and fill rate based on results of a MIC simulation using the current G402A equations and 30/15 day stockage policy. The 30/15 notation will be used throughout this document; the first number represents the stock level (30 * DDR) and the second represents the reorder point (15 * DDR).

A SLAM II simulation program was developed that included the capability to simulate and test MIC inventory models and compute performance statistics for alternative stockage models. Simulations were run that individually varied

the following parameters: 1) average number of days between requests, 2) average quantity per request, and 3) the form of the demand distribution.

The SLAM II program simulations provided expected unit and line item fill rates for various combinations of demand distribution parameters. Based upon the simulation results, it was possible to infer what range of demand distribution parameters would be required for the stockage model to meet the MIC 95 percent fill rate objective.

While a more deterministic or straightforward approach would have been preferred to simulation, the literature consistently suggested that demand patterns were more complex than those described by normal or simple Poisson distributions. References were reviewed that dealt with deterministic and probabilistic relationships between demand and service levels. However, they all considered demand and O&ST as either constant, normally distributed or distributed according to a simple Poisson process. Therefore a more robust approach was necessary that was not as constrained by assumptions regarding the demand and O&ST distributions. Thus, the approach used with the MIC was simulation.

Determining D033 VMR Assumptions. This section relates specifically to the case where the MIC does not stock the part and support is from DS. As noted earlier, an AFLMC study performed by Blazer reviewed the assumed VMR in the equation for the safety level in SBSS. It was noted on page 21 the equation was:

$$SLQ = [3 \times (O\&STQ)]^{1/2}$$

where the safety level is multiplied by a "C" factor depending upon the objective percentage of time a part request should be satisfied during the

replenishment cycle. The safety factor C, "is typically set to 1" which implies an 84 percent fill rate during replenishment (22:2).

In Dr. J. Wayne Patterson's study of alternative forecasting techniques for the SBSS, he specifically stated "3 [in the SLQ equation] has been historically determined as the lead time demand variance/mean ratio" (22:2). Dr. Patterson's statement could arguably raise the hypothesis that any number X in the place of "3" in the above SLQ equation implies that SLQ equation could support a VMR approximately equal to X, perhaps given some upper and lower bounds on X.

As indicated on page 15, the current D033 equation for safety level quantity (SLQ) is:

$$SLQ = [(\#demands/DE)^{*}(DDR^{*}PLT)^{*}(SCF/\#demands)^{2}]^{1/2}$$

which is obviously different than the version discussed by Blazer and Patterson. However, according to an internal AFLC report, at one time (circa 1978) D033's SLQ equation was the same as the SBSS SLQ equation discussed earlier (14:44). To some degree this would infer that the expected VMR for parts demands against D033 was 3:1.

Hypothesizing that a number X (from the SLQ equation) approximates the assumed VMR, the current D033 SLQ equation can be algebraically rearranged to parallel the earlier SBSS equation. Specifically, in the current D033 SLQ equation the term (DDR*PLT) equates to the "O&ST" term in the earlier SBSS equation. Therefore the current D033 SLQ equation can be reexpressed as:

$$SLQ = [(\#demands/DE)^{*}(SCF/\#demands)^{2}\,{}^{*}O\&ST]^{1/2} \qquad (16)$$

where the term (#demands/DE)*(SCF/#demands)^2 equates to the "X" concept hypothesized from the Dr. Patterson statement. Provided demand variance or VMR was a function of the included variables, this type of equation could

arguably support variable VMR's, as was the effect of Blazer's recommendation to modify the SBSS stockage models.

In summary, literature review and personnel interviews did not discover any specific demand VMR for which the current D033 SLQ equation was designed. Therefore, this study tentatively accepts for research purposes the above notion that the implied VMR supported by the D033 SLQ is:

$$VMR_{(implied)} = (\#demands/DE)^{*}(SCF/\#demands)^{2} \qquad (17)$$

Therefore, the method used to test if D033 adequately forecasts VMR was to compare the observed VMR (for simulated demands) with the implied VMR per the tentatively hypothesized equation above. The simulation computes a standard deviation for the observed VMR. A lower tailed Student *t*-test with level of significance equal to 0.1 was used as the test to infer if the implied VMR adequately forecasts simulated VMR. Beyond the above method, a *simulation approach to investigating D033 would provide insight to its* performance and limitations, however, such an undertaking is beyond the scope and time limitations of this research.

Simulation of Alternative Models

Experimental Design. The strategy was to: 1) develop a SLAM simulation model, 2) make multiple runs of varying model parameters, safety level & reorder models, and 3) collect performance measures such as statistics on fill rates, backorders, and service levels.

Simulated Demand Data. The simulated demands depends on two distributions. An exponential distribution was used for interarrival times (based on an average-β) for demands. A Poisson (with an average lot size λ, $\lambda >= 1$) for actual quantity requested given a request is created via the exponential distribution.

SLAM II Model Logic. The SLAM II program is a combination of SLAM II network statements and FORTRAN inserts. FORTRAN subroutines were necessary for the statistics and specific reports for the simulated 15 years (30 six month cycles) of operation.

The simulation consists of three different files: MIC.DAT which contains the SLAM II network statements (initialization and control statements); MAIN.FOR which contains the FORTRAN routines which do the inventory and policy modeling and all of the customized report generation; and PARAM.INC which dimensions the FORTRAN arrays. The functions of MIC.DAT and MAIN.FOR will be explained in the next few paragraphs. Macro flowcharts and a copy of the source code are included as Appendixes L and N, respectively.

MIC.DAT controls the timing and sequencing of events within the network. The network generates orders based on an exponential distribution with average β days between requests. It then uses a Poisson distribution to determine the specific number of units requested for the item under consideration.

Copies of requests are accumulated at the end of each day; the total number of demands (or zero) are "observed" to statistical register(s) for later determination of daily demand rate variances, means, and VMRs. These requests are also being accumulated on a 180 array for weekly calculation of DDR, stockage objectives and reorder points.

While a copy of the request is being accumulated for stockage objective computations, the original copy of the demand is processed by a request subroutine that determines if a total fill can be made from on-hand stock, or a partial fill with partial backorder, or if a total backorder is required.

If fills can be made (total or partial), the on-hand stock is reduced accordingly and statistical observations are made on fill rates at the unit and line item levels. Backorders (if any) are filed awaiting possible fulfillment with the next replenishment receipt, and partially filled backorders are refiled with the remaining quantity left on backorder. Time persistent statistics are kept on backorders to assess average numbers and backorder-days (a rough parallel to NMCS days, Not Mission Capable-Supply).

Following any request for stock, the releveling routine is called to assess if the inventory position (on-hand + on-order - backorders) is less than the latest computed reorder point. If the inventory position is below the reorder-point (ROP), a request is generated and a shipment is scheduled to arrive at the (MIC) an O&ST later. The actual O&ST is randomly selected according to a lognormal distribution.

The MIC network model automatically calls for recomputation of the stockage levels every seven days. The model is run for 200 days to fill the 180 day array with history and to get pass the initial transient period. At 200 days the statistical registers are cleared and normal operations continue. Every 180 days after the transient period the network calls the output subroutine which calculates summary data and statistics. Included in the six-month reports are measures of the observed unit fill rates (UFR), line item fill rates (LIFR), number of requests and total units, variance of demands, VMR, number of backorders, and number of backorder-days.

At the end of the simulation (200 day transient period plus 30 six month sequential periods), an overall summary report is created that includes grand averages and standard deviations of the performance measures.

The multiple-batch sequential method of simulating is used to reduce possible bias and random variances and to provide adequate observations to invoke the central limit theorem--that given enough observations (generally 30+) of random variable $\bar{X}$, the mean of $\bar{X}$ ($\bar{\bar{X}}$) is approximately normally distributed with the standard deviation of $\bar{\bar{X}}$ equal to the standard deviation of observations of $\bar{X}$ divided by the square root of the number of computed $\bar{X}$s. The standard deviation of $\bar{\bar{X}}$ is also referred to as the standard error

Experimentation. The start up transient period for the stock level computations is approximately 180 days as both the D033 and G402A stockage logic require 180 days of demand history before using a steady technique to determine days experience (DE), Daily Demand Rates (DDR) and (six month) usage averages.

Prior to 180 days of history, G402A uses whatever history is available divided by the corresponding time length. If there is less than 180 days of history in D033, it divides the cumulative requests by 180 days (4:8-1) (assuming there have been the two or three (XF/XB) requests required for stock level computation) (9:17-1).

An extra 20 days was used beyond the 180 to account for any last transients from MIC replenishments (shipping time) from the last transient MIC releveling at about 180 days.

In summary to this point, the methods outlined will be used to assess the implied assumptions of the stockage models, to analyze actual characteristics of the demand data, and to simulate actual demands as part of a simulation and evaluation of alternative MIC stockage polices.

IV. Findings and Analysis

Overview

Data analysis will be presented first, followed by an analysis of stockage policy assumptions, and lastly, evaluation of alternative stockage policies.

Data Analysis

Analysis of Actual Demand. The parts issue request transactions were edited and entered as DOS data sets on a microcomputer. The BASS statistical package was used for data analysis and to compute inferential statistics. A copy of the BASS application code program is given in Appendix D.

The BASS program used the demand data to compute a DDR and VMR (of DDR) for each NSN. Then, it categorized each NSN's observed VMR into a group. The VMR groups were [0–4), [4–10), [10–30), [30–40), [40–100), and [100+. These groupings paralleled those used by Blazer (6:12). The BASS program derived the average days between requests (DBR) by computing

$$\text{average days between requests} = 110 \text{ days} / \text{number of requests} \qquad (18)$$

The average days between requests were then categorized by group--the horizontal axis in Figure 4 shows the groupings. (Also, the average quantity of units demanded per request (UPR) was computed and categorized.) A cross-tabulation was performed for the VMR (of DDR) and average days between requests groupings. Figure 4 and Figure 5 represent relative the frequency of the crosstabulated data for MIC MCC (aircraft) and MIC MDD (electrical component repair). In Figure 4 and Figure 5 the horizontal axis represen‹· :he grouping by average days between requests, and the stacked bars show the relative frequency of VMR groups.

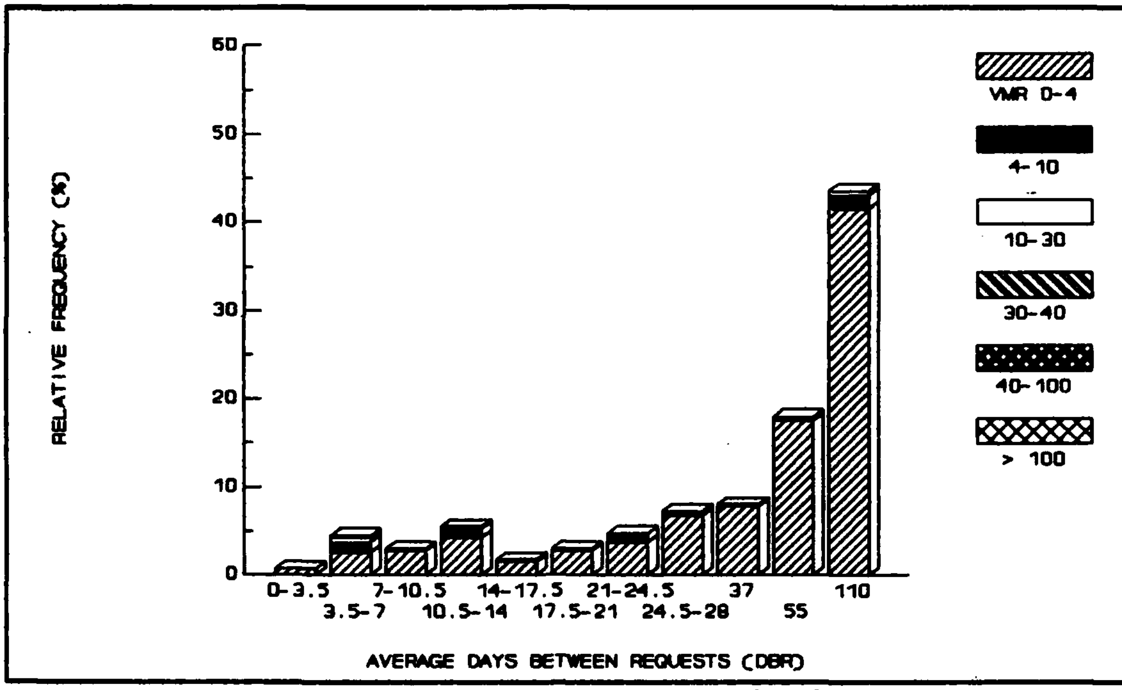

Figure 4. MCC Demands at NSN level

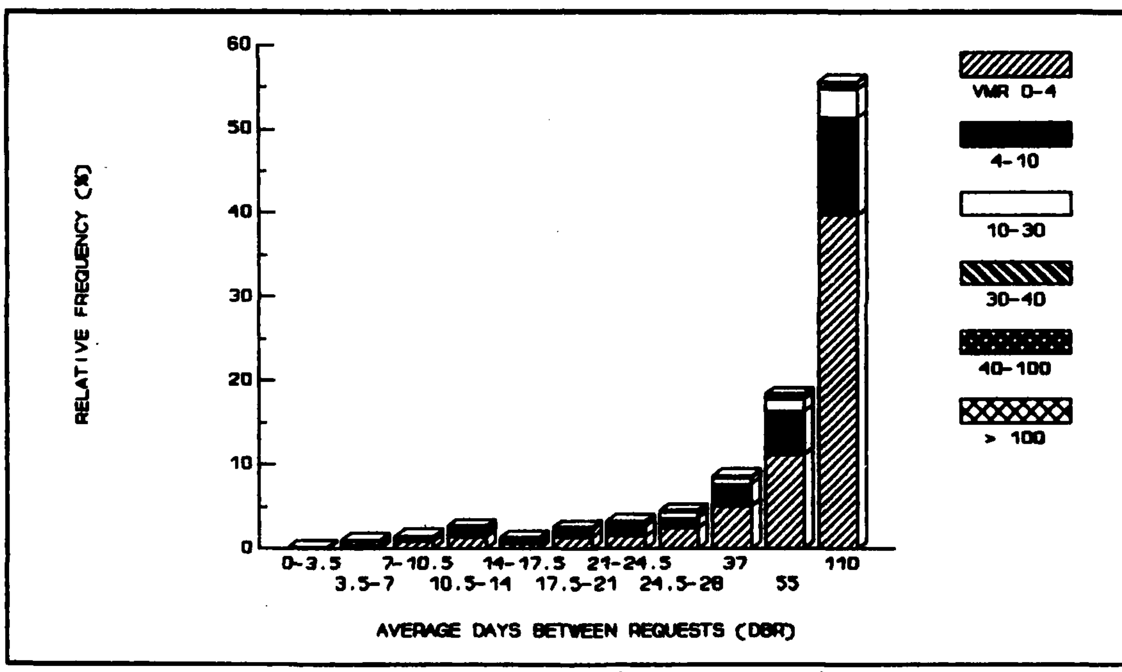

Figure 5. MDD Demands at NSN Level

As Figure 4 shows, most of the NSNs were only requested once or twice during the 110 days, and most of the NSNs had a VMR between zero and four. Similarly, Figure 5 shows most NSNs had only one, two or three requests within the 110 days, however, more of the NSNs had a VMR between four and ten. Figure 4 and Figure 5 are at the NSN line item level--weighing an NSN with one request for one unit the same as an NSN with 30 requests for multiple units.

Figure 6 and Figure 7 show the same stratification for MICs MCC and MDD, respectively, except they are weighted by the number of units requested for each NSN during the 110 days. As expected, and as noted by Brown and others, a few NSNs contribute to a disproportionate number of the units requested. As Figure 6 indicates, the group of NSNs which contributed the most to total number of units demanded was the group averaging from 3.5 - 7 days between requests. In this case, approximately one-forth of the units demanded were from approximately five percent of the NSNs. Further, a significant portion of the MIC MDD demands were for NSNs experiencing very high VMRs (40-100 and 100+).

Similar bar charts are presented for the other three MICs in Appendix E. The graphical evidence in Figure 4 through Figure 7 and Appendix E strongly suggests that the demand distributions (VMR and frequency of demands) at the MIC level differ depending upon the product area supported. Current MIC stockage Policy does not acknowledge this fact.

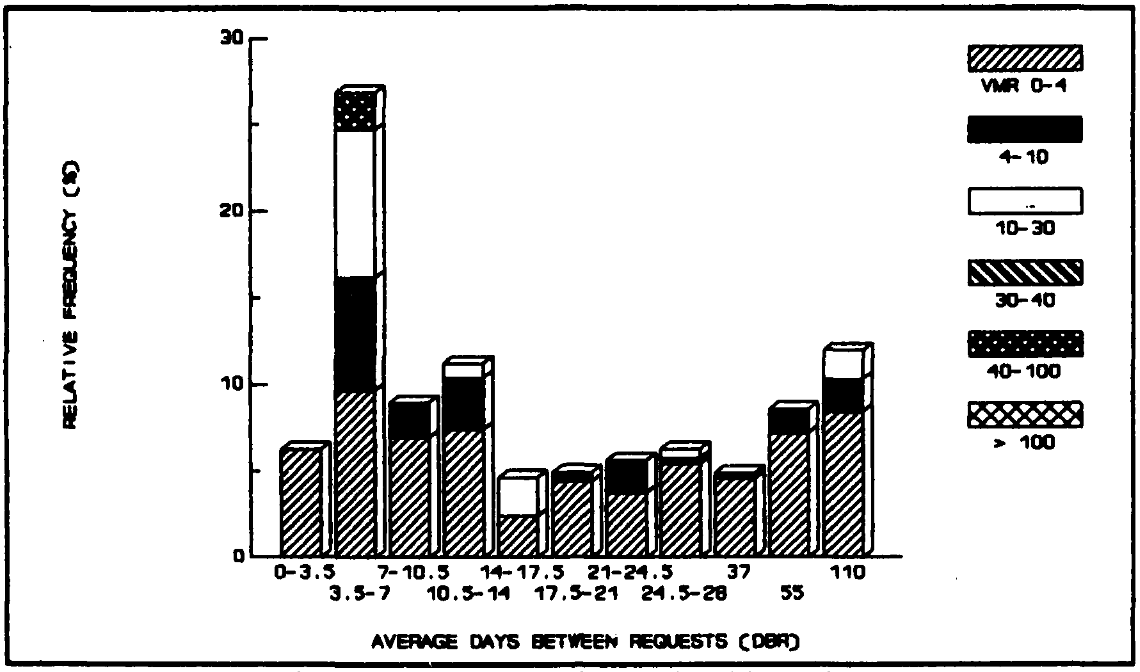

Figure 6. MCC Demands Weighted by Units

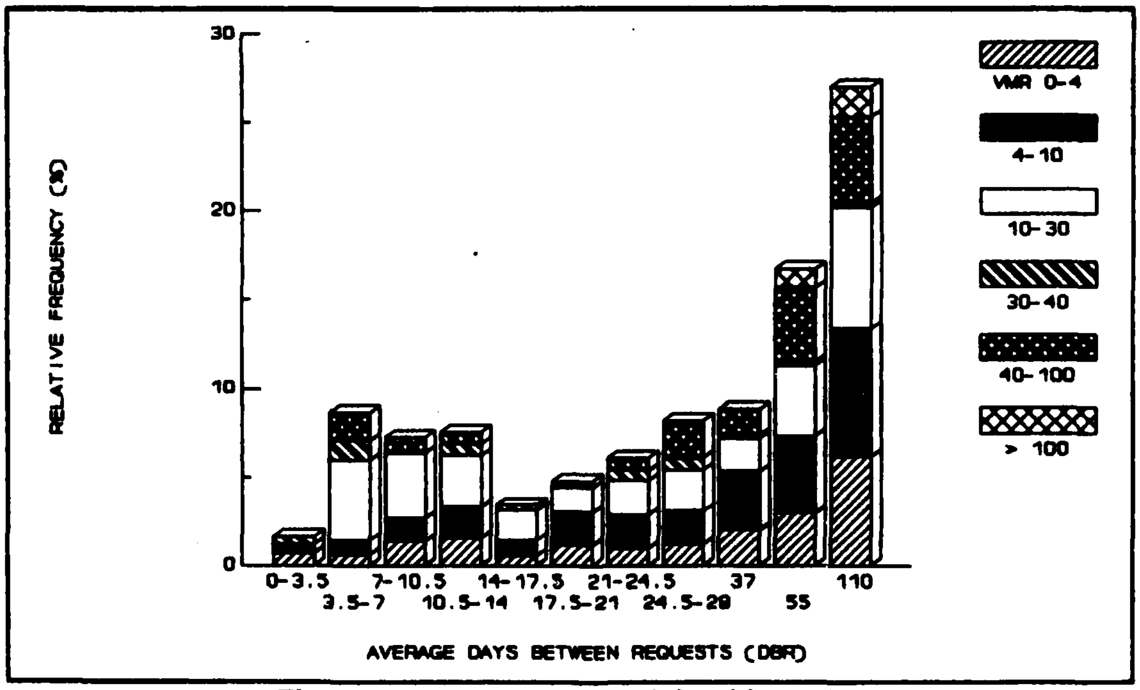

Figure 7. MDD Demands Weighted by Units

In addition to DDR, VMR, and average DBR, MIC demands were analyzed for average number of units demanded per request (UPR). Table 4 reflects some overall comparative statistics for the five MICs.

Table 4. Comparative MIC Demand Characteristics

MIC	DDR	VMR	UPR	STD DEV UPR	AVE DBR
MCC	0.054	2.03	1.51	1.75	65.77
MDD	0.105	6.30	5.16	11.27	77.73
MFF	0.273	11.88	8.75	26.02	50.01
MGG	0.208	10.93	9.28	15.43	81.65
MJJ	0.105	8.93	7.61	7.61	91.01

As noted in Figure 4 through Figure 7 and Table 4, demands for most MIC items tend to show considerable variability--with the apparent exception of MIC MCC (aircraft) which shows a lower VMR and standard deviation of UPR. Table 4 shows overall UPRs for the five MICs. The UPR and its standard deviation for MIC MCC are significantly smaller than the other MICS.

It was observed that many NSNs had multiple demands for approximately the same quantity for every request--a variance to mean ratio of units per request (VMR_UPR) equal to zero. This lead to the conclusion that a portion of the demands could be described by a constant Poisson process (CP, with a constant lot size), and the remainder by a compound Poisson process such as PP where the compounding UPR function is also Poisson. Recall Figure 3 on page 33 illustrated the notions of simple Poisson, constant Poisson (CP), and compound Poisson (PP) distributions.

By definition the UPR of a constant Poisson process should be constant, or show small variance (reference earlier literature review on Blazer and

AFLMC). A constant UPR leads to zero or small variance which in turn leads to zero or small VMR_UPR. Conversely, the variance of a compound Poisson process with varying UPR will be greater than zero, which in turn leads to a VMR_UPR of greater than zero. For a perfectly defined Poisson-Poisson (PP) process the variance of the UPR will be equal to the average of the UPR, which in turn leads to a VMR_UPR of 1:1.

The actual demand data base was divided into two groups--one with VMR_UPR less than or equal to 0.25 (judgementally set as an upper limit for constant Poisson) and a second group with greater VMR_UPR (for compound Poisson). For each of the two VMR_UPR groups, the demand data was then crosstabulated by average UPR group and DBR group. The average UPR groups were defined as [1-1.2), [1.2-4), [4-10), [10-30), [30-40), and [40-100]. (Only 11 of the approximately 4660 NSNs studied had an average UPR greater than 100.) The resulting data for MICs MCC and MDD are presented in Table 5 and Table 6, respectively.

Table 5. Crosstabs of MCC Demands

MIC MCC %	DBR 3	5	9	12	16	18	22	28	37	55	110	TOTAL
CP1	4.4	14.0	5.7	6.6	2.3	2.3	4.2	4.4	4.6	7.1	9.1	64.4
CP2	2.6	6.1	4.1	4.7	0.0	1.2	0.6	2.6	1.4	1.3	1.0	25.5
CP7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.6
PP2	0.0	1.1	0.0	0.6	0.5	1.2	1.0	0.5	0.2	0.6	0.6	6.2
PP7	0.0	2.4	0.0	0.0	0.5	0.0	0.3	0.0	0.0	0.0	0.1	3.2
P20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
TOTAL	7.0	23.5	9.8	11.9	3.2	4.6	6.1	7.4	6.2	9.2	11.2	100

CP = constant Poisson PP = compound Poisson (n = 400)

The columns in the tables represent average DBR group. The codes on the left side of the table represent the distribution type (CP versus PP) and the approximate midpoint (average UPR) of the group represented by the row.

Table 6. Crosstabs of MDD Demands

MIC MDD %	DBR 3	5	9	12	16	18	22	28	37	55	110	TOTAL
CP1	0.0	1.6	1.5	2.6	0.9	1.3	1.5	1.5	2.6	4.3	8.4	26.1
CP2	0.9	0.2	1.3	1.9	0.3	1.0	0.6	1.5	2.8	4.3	4.4	19.2
CP7	0.0	0.0	0.0	0.0	0.0	0.2	0.1	0.2	0.6	1.4	0.6	3.0
PP2	1.8	2.3	2.8	3.0	1.3	2.4	2.5	2.1	2.5	2.4	3.3	26.3
PP7	0.5	3.3	1.2	1.1	1.0	1.3	1.3	1.5	1.5	1.3	4.1	18.0
P20	0.0	1.2	1.1	0.9	0.4	0.3	0.6	0.6	0.5	0.5	1.4	7.4
TOTAL	3.2	8.5	7.8	9.5	3.8	6.3	6.7	7.3	10.5	14.1	22.2	100

CP =constant Poisson PP = compound Poisson (n = 7128)

The MCC data in Table 5 shows a concentration of requests in the ranges denoted as constant Poisson distribution with mean quantity requested equal to one or two. Less than 10 percent of the MIC MCC requests are categorized as compound Poisson. This is in contrast to the data for MIC MDD in Table 6. Over 50 percent of the MDD demands have a UPR_VMR greater than 0.25 and have been categorized in the PP range. Approximately 70, 68, and 40 percent of the demands levied against MICs MFF, MGG and MJJ have a VMR_UPR greater than 0.25, respectively (reference Appendix F).

The numerical presentation also strongly supports the hypothesis that demand characteristics are related to the MIC or product. It follows that different MICs and product areas will experience different supply requirements and stockage policies should be tailored to those differences.

MIC Intransit Days. MIC intransit transactions for MIC MSS were collected for a 30 day period. Figure 8 shows a frequency bar chart of the observed intransit times.

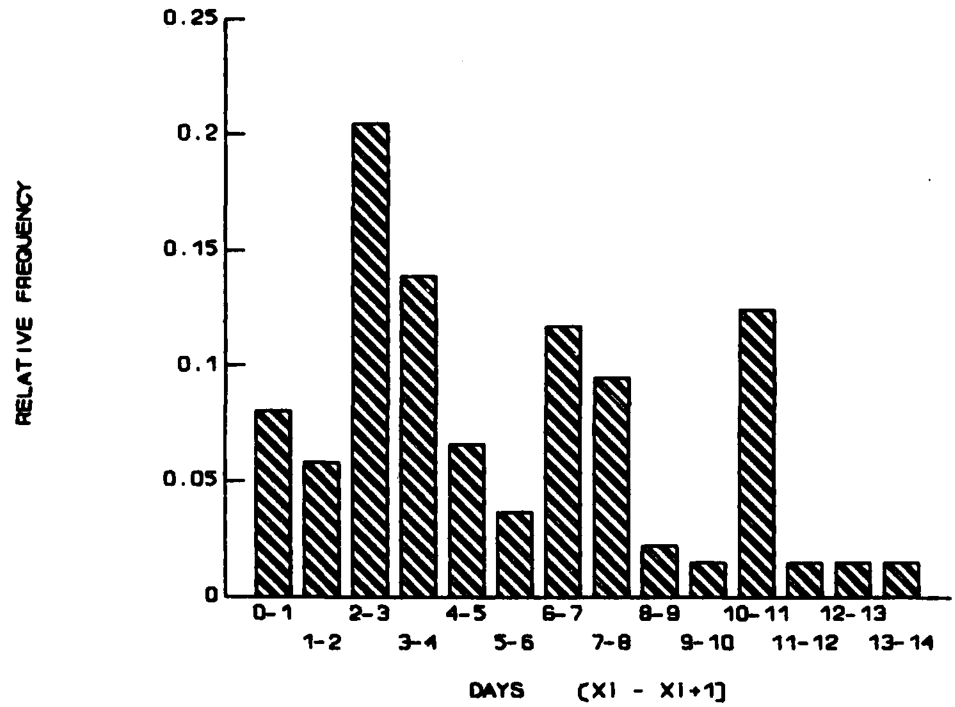

Figure 8. Observed Intransit Days from DS to MIC MSS (n=137)

For the intransit data to be useful, pairs of intransit notices and intransit clear transactions were required to compute actual intransit times. Some of the data did not have the matching transaction due to the timing of the collection. After sorting and purging of transactions without matches, 137 complete observations of intransit time were left.

Using the observed intransit times, a five percent trim mean procedure was applied to the ordered data to "yield a measure that is neither as sensitive to outliers as the mean nor as insensitive as the median" (13:17-18). The resulting data set was input into the AID curve fitting program written by

Pritsker and Associates. The AID program did not reject the hypothesis that the intransit time data was distributed according to a lognormal distribution with mean 5.46 (days) and standard deviation equal to 3.68 (days), at a 0.05 significance level using a Kolmogorov-Smirnov test. Figure 9 shows the hypothesized lognormal distribution of intransit times based on the observed data after applying the five percent trim mean to reduce sensitivity to outliers.

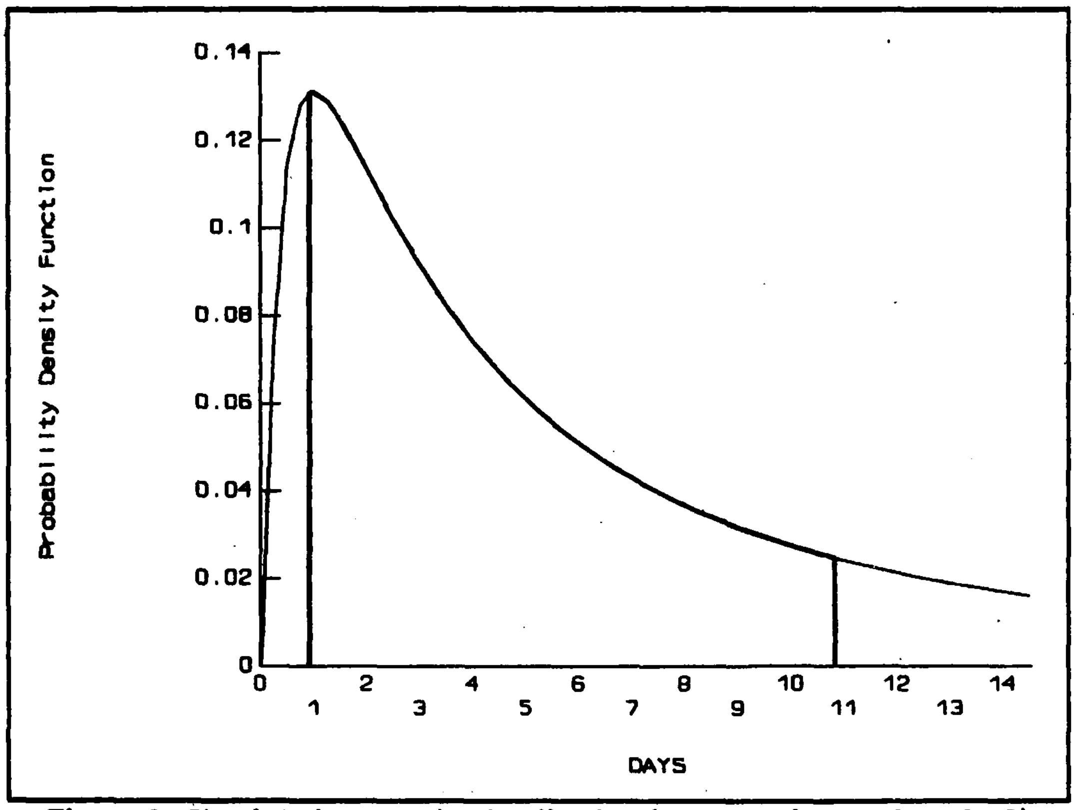

Figure 9. Simulated Intransit Distribution (Lognormal μ=5.46, σ=3.65)

The vertical bars in Figure 6 represent the smallest (.919 day) and largest (10.831 days) observed intransit times within the trimmed data set.

Intransit times also include the time it takes from when the MIC or MA material receiving area personnel certify receiving the material to when the intransit is cleared back to D033. In a telephone interview with a MIC MSS representative, time estimates for optimistic (a), pessimistic (b), and most

likely (m) were determined for the amount of time between certifying receipt of intransit material and when the intransit transaction was actually cleared back to D033. The times were 24 hours, 0.5 hours, and 2 hours, respectively (21). Using the equation for the mean of a PERT-beta distribution (23:706)

$$\mu = (a + 4^{*}m + b)/6 \tag{20}$$

where a is the optimistic value, b the pessimistic value, and m the most likely, a mean time of 5.416 hours (0.225 day) was computed.

The simulated intransit times where taken from the hypothesized lognormal distribution with limits as suggested by the trimmed actual data minus 0.225 day as the expected time for the MIC personnel to process the MIC intransit transaction back to D033.

Determining Current Statistical Assumptions

MIC Demand Assumptions. As noted in the literature review, Blazer and others found implied assumptions regarding VMRs in the SBSS safety level equation (6;22). One of the objectives of this research was to determine what, if any, implied assumptions existed regarding MIC stock levels and reorder points. Based on the SBSS related literature, a logical hypothesis to test was if a strong correlation existed between VMR and fill rates as provided by the MIC reorder point technique. And if such a correlation existed, what VMR would be associated with a 95 percent fill rate. The test of this hypothesis is discussed in the subsection entitled "First Simulation". Based partially upon the results of the first simulation, the hypothesis and test were modified; these second tests are discussed in the subsequent subsection entitled "Second MIC Simulation".

First Simulation. Demand distribution parameters used in the first simulation were from an AFLMC study that tabulated a sample of 40 items to

"represent typical Air Force Consumables in terms of the demand rate and variance of demand"(5:15-17). The specific parameters used in the first simulation were for 20 of the 40 base-level items sampled by AFLMC.

While demand patterns at the depots and bases could be arguably different, they should be sufficiently similar for the testing of potential correlation between VMR and fill rate when the demand patterns are simulated using the current MIC stockage logic (G402A system). Sample demand distribution data used is included as Appendix B.

Request demands and MIC performance for the 20 items from the AFLMC study were simulated. VMRs and fill rates were generated for 30 six-month periods (15 years). The r^2 correlation between VMRs and fill rates was 0.0511. A value close to zero strongly suggests that there is no relationship between VMRs and fill rates under the current MIC 30/15 stockage model.

However, in compiling and sorting the simulation data in various arrays, there did appear to be a relationship between average days between requests (DBR) and fill rates. Therefore, second simulations were designed with DBR as a prime variable or treatment. As noted earlier in this chapter, analysis of actual demand data had indicated the differences in demands based on UPR and the demand distribution (CP versus PP). Therefore, the UPR and demand distribution were also used as independent variables in the second round of simulations.

The first and second rounds of simulations were run under the assumption that if there is a MIC stock record for an NSN then DS (D033) always had enough stock on hand to fill MIC replenishment requests. Therefore the intransit times simulated were strictly normal DS-MA intransit times and did not include any procurement or wholesale level O&ST. To the extent this

replenishment assumption is optimistic, the simulation fill rates are also optimistic. In other words, the simulated fill rates can be considered an upper limit; the performance of the MICS must be considered in light of replenishment support from DS(D033).

Second MIC Simulation. Simulations were run for 196 different combinations of DBR, UPR, and constant-Poisson versus Poisson-Poisson demand distributions.

The simulated line item fill rates (LIFR) corresponding to a 30 day stockage objective and 15 day reorder point policy are shown in Table 7. The table consists of cells with the simulated grand average LIFR for each set of the parameters simulated. For instance, the cell in the top left corner represents the performance measures when the simulation was run using a constant Poisson (CP) distribution and an order quantity of one (CP1), and demands distributed according to a Poisson process with an average of 3 days between requests.

The statistic of interest at this point is the line item fill rate (LIFR). The LIFR will be used for comparison with the 95 percent fill rate objective for items that "match" a MIC stock record. In other words, a request can not be filled unless it matches an NSN that is stocked.

The amount of variability of the 30 six-month line item fill rates about the LIFR value was computed in terms of "standard error". The standard error approximates the standard deviation of the LIFR. The standard error varied with each set of input parameters--lower with the small and more frequent requirements, and larger standard errors otherwise. For the cells with a LIFR equal to or greater than 90 percent the average standard error equaled approximately 0.01.

Table 7. LIFR Performance of 30/15 MIC Stockage Policy

	(AVERAGE NUMBER OF DAYS BETWEEN REQUESTS)										
LIFR	3	5.25	8.75	12.25	15.71	18.33	22	27.5	36.66	55	110
CP1	0.99	0.99	0.99	0.99	0.97	0.96	0.95	0.94	0.96	0.94	0.73
CP2	0.99	0.97	0.92	0.91	0.86	0.86	0.82	0.78	0.64	0.56	0.08
CP7	0.99	0.98	0.90	0.87	0.84	0.79	0.71	0.58	0.47	0.11	0.00
PP2	0.99	0.96	0.91	0.89	0.84	0.82	0.78	0.71	0.66	0.62	0.47
PP7	0.99	0.96	0.91	0.85	0.81	0.78	0.72	0.61	0.49	0.40	0.19
PP 20	0.99	0.96	0.90	0.87	0.75	0.71	0.65	0.51	0.38	0.15	0.04

CP = Constant Poisson   PP = Compound Poisson

The standard error was used to determine the lower bound for claiming whether a set of parameters supported the MIC 95 percent fill rate critéria. The limit was set at 95 percent minus two standard errors. In other words, 93 percent [.95 − (2*.1)] was considered to be approximately equal to a 95 percent fill rate with the 2 percent difference being attributable to random chance. Using the 93 percent criterion, 20 of the 66 parameter sets would satisfy the initial step of the test--mostly the top row and left column of Table 7. This means the other 46 sets didn't achieve 95 percent fill rates.

The D033 TVA report states an objective that 85 percent of the parts requests match a stock record (the NSN being loaded in the MIC details) (reference Appendix A). Thus to claim the current MIC stockage policy provides 95 percent fill rates, approximately 85 percent of the actual demands should occur in the 20 cells satisfying the fill rate criterion. Table 8 shows the

estimated percent of demands levied against each MIC that satisfied the 95 percent fill rate criterion.

Table 8. Percent of MIC Requests within Implied Demand

MIC	Percent of Demands
MCC	67.54
MDD	27.89
MGG	14.65
MFF	0.45
MJJ	16.97

In reviewing the actual demands, at most only 68 percent of the demands (levied against MIC MCC) occurred in the 20 cells meeting the 95 percent fill rate objective. Less than 30 percent of the demands for MIC MDD occurred in the 20 cells meeting the objective. Therefore, the data does not support the claim that the current MIC 30/15 stockage model based on DDRs will support a MIC 95 percent fill rate objective.

An intermediate review is appropriate regarding implied MIC assumptions about demand. Unlike the SBSS and its statistically oriented safety level equations, the simplistic DDR approach of MIC reorder level does not show any direct correlation between VMR and fill rates. Rather, the MIC reorder point policy and its resulting fill rates are related to DBR and UPR. Thus leading to the conclusion that a robust MIC stockage policy should also be oriented to DBR and UPR. The D033 implied assumptions regarding VMR will be discussed and tested in the next section.

D033 VMR Assumptions. This section is for the case where parts support is direct from DS to MA and here is no interceding MIC stockage. In Chapter III, a method was developed to approximate the D033's implied/assumed demand VMR. Note, the origins of the logic was with the SBSS and satisfying an 84 percent fill rate during O&ST. Specifically, the following equation (17) was derived:

$$VMR_{(implied)} = (\#demands/DE)*(SCF/\#demands)^2$$

where DE was days experience and SCF was the number of units demanded during the days experience on record.

The ability of the current D033 SLQ equation to forecast actual VMR was tested by using demand parameters and resultant VMR observations from the second simulation. The simulation computed an average number of requests (# demands) and number of units demanded (SCF) per six month period. Considering 180 days a typical data history maintained D033, the simulated averages were used as inputs to equation 17.

The equation used to compute the test statistic value in the lower tailed t test is (13:297):

$$t = \frac{\bar{x} - \mu_0}{s/(n)^{1/2}} \qquad (19)$$

where $\bar{x}$ will be interpreted as the implied VMR (Eq 17); μ_0 is the VMR from the second simulation; s is the standard deviation of the VMR from the simulation, and n equals 30 (for the 30 six-month periods simulated). Recall, the UPR and DBR values were input as parameters into the second simulation. The simulation, however, outputs descriptive data on demands, such as observed VMR. Thus, an implied VMR can be calculated and compared to the observed

VMR. The critical t value for a 0.1 level of significance with 29 degrees of freedom [30 (simulation periods) − 1] is 1.311.

The MIC demand distribution crosstab matrices (Figure 6 and Figure 7) were used for determining which combinations of demand parameters to test. A sample of ten each cells with the highest frequency of demands were used from the crosstabs for MCC and MDD. MCC was used due to its apparent consistency and MDD because it had the most demands of the non-aircraft MICS. The corresponding average number of demands (DE) and number of units requested (SCF) demand parameters were extracted from the second simulation's output. These values, along with the simulation's computed VMR and standard error, were entered into a spreadsheet. From this, the implied VMR and t statistic were computed.

The null hypothesis (H_0) was that the D033 SLQ implied a VMR that was equal to or greater than the VMR computed in the simulation. As a lower tailed test, the rejection region occurs where the computed t test statistic is less than the t critical value.

The implied VMR and t test statistic were calculated for the 20 sets of demand parameters. Nineteen of the 20 tests rejected the null hypothesis. The one test that did not reject was for a combination of fairly large lot size (units per request) and demand frequency. A second group of ten sets of data were extracted from the MIC MDD matrix. These represented a cross section of high lot size and high to medium demand frequency. These demand parameter sets were input into the spreadsheet and tested; only five of the ten sets rejected the null hypothesis. Specific data and results are provided as Appendix K.

The "items" for which the SLQ equation (Eq 16) adequately implied a VMR were all grouped together in the high quantity, high frequency ranges (bottom

left of crosstab tables). Using the MDD crosstab table as a gauge, less than eight percent of the demands fell into one of the cells which did not reject H_0 in the *t* test. In other words, 92 percent of the items tested had observed VMRs exceeding what is allowable by the D033 safety level equation.

The hypothesized logic and test results suggest that for those items receiving support directly from D033 (where a MIC does not stock the item) approximately 92 percent of the items (in the case of electrical components) would probably receive an average fill rate (during D033 O&ST) of less than 84 percent. In other words, when using the current safety level equation to set the reorder point, the D033 system could not meet its monthly target of 95 percent fill rate for those items (stock records) also undergoing O&ST in the same month.

However, as noted in Chapter II, D033 uses the greater of four alternative calculations to determine the reorder point. Therefore the real impact of this finding is somewhat clouded. Additional research into the ability of D033 to meet its fill rate objective is recommended.

Simulation of Alternative Models

Two MIC stockage policies were simulated in addition to the 30/15 MIC policy--a 7/3.5 stockage level and reorder point policy, and a modified lot-for-lot stockage policy.

7/3.5 Day MIC Stockage Policy. This alternative MIC simulation model represented a policy where the stockage objective equaled the DDR * 7 (days), and the reorder point equaled DDR * 3.5 (days). The results of the 7/3.5 simulation are shown in Table 9.

For ease in comparison, the results presented for this and the next alternative MIC stockage policy are presented in the same format as the 30/15

Table 9. LIFR Performance of 7/3.5 MIC Stockage Policy

	(AVERAGE NUMBER OF DAYS BETWEEN REQUESTS)										
LIFR	3	5.25	8.75	12.25	15.71	18.33	22	27.5	36.66	55	110
CP1	0.79	0.78	0.67	0.69	0.75	0.79	0.79	0.85	0.89	0.93	0.92
CP2	0.52	0.48	0.48	0.25	0.02	0.01	0.00	0.00	0.00	0.00	0.00
CP7	0.46	0.42	0.28	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PP2	0.56	0.54	0.49	0.41	0.40	0.39	0.35	0.34	0.38	0.33	0.40
PP7	0.49	0.45	0.33	0.22	0.19	0.15	0.15	0.11	0.09	0.08	0.06
PP 20	0.44	0.41	0.21	0.08	0.03	0.03	0.01	0.00	0.00	0.00	0.00

CP = Constant Poisson PP = Compound Poisson

simulation. As can been seen in the table, the fill rates are lower and the backorder-days higher with the 7/3.5 policy than they are in the 30/15 policy. This is due to significantly lower levels of stock held in MIC than 30/15 policy--approximately one forth the levels (30 divided by 7).

Lot-for-Lot MIC Stockage Policy. The stockage objective and reorder point logic in the third alternative MIC stockage policy is best described as a hybrid. The stockage level and reorder points are designed to support the expected quantity to be requested, with consideration to variance of quantity requested per demand. It can use the DDR to apply a limit on the stockage objective and therefore preclude extremely large "safety levels" due to outliers in VMR. Otherwise, it avoids the naivety of DDR's.

The reorder point logic is a combination of lot size and adaptation of the safety level equation recommended by AFLMC. In the simulation, it behaves as an "S, S-1" stockage model where the reorder point is one less than the

stockage objective. The results of the third MIC stockage policy are presented in Table 10.

Table 10. LIFR Performance of Lot-for-Lot MIC Stockage Policy

	(AVERAGE NUMBER OF DAYS BETWEEN REQUESTS)										
LIFR	3	5.25	8.75	12.25	15.71	18.33	22	27.5	36.66	55	110
CP1	0.96	0.93	0.88	0.88	0.86	0.84	0.85	0.88	0.92	0.95	0.92
CP2	0.93	0.86	0.72	0.71	0.79	0.80	0.82	0.88	0.91	0.94	0.92
CP7	0.90	0.81	0.67	0.71	0.76	0.79	0.81	0.86	0.90	0.94	0.90
PP2	0.91	0.82	0.78	0.83	0.85	0.86	0.86	0.91	0.92	0.91	0.80
PP7	0.90	0.81	0.71	0.78	0.81	0.81	0.83	0.87	0.89	0.90	0.80
PP 20	0.90	0.80	0.67	0.71	0.75	0.75	0.78	0.79	0.83	0.89	0.82

CP = Constant Poisson PP = Compound Poisson

Essentially, the stock level is set equal to the larger of two equations. The first is equal to the mean historical lot size plus 1.65 times the standard deviation of the historical quantities demanded per request (exponential smoothing with smoothing factor a=0.03 was used in the simulation to compute a mean historical lot size). The second was a derivation of the safety level equation recommended by Blazer in his study of the SBSS. The second equation has two parts to it--the first part represents an O&STQ (DDR * observed intransit days minus 0.225 for internal MA movement and clearing the intransit). The second part parallels Blazer's recommendation in accounting for demand and O&ST variability in the safety level equation.

The MIC stock level equation used in the simulation is:

$$SCL = \lceil 5.241*DDR+1.65*SQRT(1.5*VOD+(DDR**2.0)*VOO)+0.9 \rceil \quad (20)$$

where ⌈ ⌉ means take integer value of enclosed. VOD stands for computed variance of demand, and VOO is computed variance of order and ship time (intransit time). The reorder point is set equal to the stock level minus one, with a minimum reorder point of one.

Comparative Performance of Alternative Policies. To facilitate comparison, simulation results for each MIC stockage policy were compiled into overall MIC measures.

The performance data for each set of simulation parameters were input to a spreadsheet. Relative frequencies from the MIC demand crosstabulations discussed earlier in this chapter were used to weigh the computed performance statistics. Overall performance measures (LIFR, UFR, backorder-days, and average on-hand inventory) were computed for each MIC by stockage policy. The aircraft support MIC (MCC) showed a significantly higher overall LIFR than any of the other MICs. Table 11 presents comparative LIFR results.

Table 11. Comparative LIFR Results

Stockage Policy	MIC MDD	MFF	MGG	MJJ	Composite "MXX"	MCC
30/15	.71	.70	.51	.56	.69	.90
7/3.5	.39	.19	.19	.38	.33	.63
Lot-for-Lot	.86	.82	.85	.88	.85	.88

Number Requests	7128	3362	314	713	11517	1558 (sample)
Number NSNs	2833	893	160	463	4349	400

The LIFRs for the non-aircraft MICs were definitely lower than the overall LIFR for the aircraft MIC MCC. The 7/3.5 policy reduced the LIFR by more than one-half for the composite MIC MXX and it reduced the MCC fill rate by approximately one-third. The modified lot-for-lot policy significantly increased the LIFR for the non-aircraft MICS and apparently lowered it somewhat for MIC MCC. Again using a composite MIC "MXX" approach to represent non-aircraft MICs, overall measures were computed for UFR, backorder-days and average on-hand inventory. These results are presented for MIC "MXX" and MCC in Table 12 and Table 13, respectively.

The average backorder-days reported in the tables represent the expected number of days actual production requests (by units) that are in backorder status for an "average" NSN in the MIC. In other words, under a 7/3.5 stockage policy, a MIC with 3000 active NSNs would incur over 920 backorder-years of waiting for parts--a significant amount of lost time and production capability. Backorder days result when the MIC stockage policy doesn't adequately allow for volume or variability of demands, or DS doesn't deliver an intransit within the expected intransit time.

Table 12. MIC "MXX" Performance Measures

MIC Stockage Policy	LIFR	UFR	Backorder-Days (per year)	Average On-Hand Inventory
30/15	.69	.81	38.3	3.7
7/3.5	.32	.49	111.4	1.3
Lot-for-Lot	.85	.89	13.8	5.5

For MIC MXX, the UFR and backorder measures improve with the MIC lot-for-lot stockage policy; however, the average on-hand inventory increases somewhat. For the composite MIC, the alternative 7/3.5 stockage policy causes backorder-days to almost triple, compared to the current 30/15 policy. Similarly, for the aircraft MIC, the backorder-days more than triple under the 7/3.5 policy.

Table 13. MIC MCC Performance Measures

MIC Stockage Policy	LIFR	UFR	Backorder-Days (per year)	Average On-Hand Inventory
30/15	.90	.93	9.7	2.2
7/3.5	.63	.71	31.8	1.0
Lot-for-Lot	.88	.90	6.1	2.0

For the aircraft MIC, the lot-for-lot policy leads to a 10 percent reduction in average on-hand levels, however, there is only a 2.2 percent decrease in LIFR--an efficient tradeoff from a cost perspective. While the lot-for-lot technique reduces overall stock levels (compared to the 30/15 policy for MIC MCC), it also reduces backorder-days. This outcome is a result of the lot-for-lot orientation towards expected request size rather than the naive DDR approach of 30/15 or 7/3.5. It reduces some stock levels while storing up the levels of others understated by the 30/15 concept. The 7/3.5 policy adversely impacts the fill rates and backorder-days for all MICs.

In review of Table 7 and Tables 9 through 13, the performance statistics point out the fact that the 30/15 and lot-for-lot approaches perform strongly in different ranges of the demand parameters. The 30/15 policy provides the best fill rates for very high demand frequencies and order quantities of one.

However, the 30/15 may also stock more units than necessary for these demand patterns; the lot-for-lot technique computes lower levels for these high frequency demands and fill rates are lower. In contrast, the 30/15 policy is weak and the lot-for-lot is strong in the more common areas where demand for an NSN is less frequent and actual quantities show more variability, such as compound Poisson demand patterns. Therefore, the MIC 30/15 stockage policy is more closely suited to aircraft demand patterns, and the lot-for-lot technique (as tested here) is more closely suited to non-aircraft demand patterns. In comparing the weaknesses, the lot-for-lot technique is only moderately weaker than the 30/15 policy in aircraft demand patterns, whereas the 30/15 technique is much weaker in the less frequent demands associated with non-aircraft MICs.

The lot-for-lot technique leads to higher on-hand levels for NSNs exhibiting infrequent and compound Poisson demand patterns. However, the quantity on-hand is more constant (than the 30/15) and the level is more closely related to the expected quantity to be requested. The 30/15 policy causes the on-hand (and on-order) level to fluctuate between 30*DDR and 15*DDR. By default, the 30/15 policy is designed not to completely fill requests for items when the average days between requests (DBR) is greater than 15 days (DBR). For instance, if the DBR for an item is consistently 20, and "16 days worth of stock" (16*DDR) is on the MIC shelf, then a request for 20*DDR will <u>not</u> be fully filled by the MIC even though the on-hand quantity was above the reorder point (according to the naive 30/15 approach). The lot-for-lot approach is much more appropriate for the variable demand patterns as found in MA.

Regarding the actual lot-for-lot (and statistical safety level) equations used in the simulation, the equations modeled have several factors that can be

used as tuning knobs to adjust performance. Only one set of factors were tested in this effort; additional experimentation into various adjustments is recommended for follow-on research. The results could further improve performance of both aircraft repair and other MIC stocks.

This chapter has examined several major areas: 1) actual demand patterns and MIC intransit; 2) the validity of assumptions implied by the MIC stockage policy and by the D033 safety level equation, and 3) the relative performance of alternative MIC stockage policies.

The next chapter summarizes the research, presents conclusions, and provides recommendations.

V. Conclusions and Recommendations

Research Summary

In Chapter 2, stockage objectives and reorder points for the MIC and D033 were discussed. The implied demand characteristics of the MIC stockage policy were approximated and found to generally not support demand at the 95 percent fill rate level. The D033 stockage and reorder points equations were discussed. Using an extension of existing research, the implied VMR of the D033 safety level equation was found to fall short of predicting actual variance in demand for the majority of items studied.

In analyzing the 13,000+ MIC demands, it was observed that some demand patterns could be described by a constant Poisson distribution and others by a compound Poisson distribution where the compounding function was also Poisson. It was further noted that the MA production areas associated with the five MICs studied showed different parts demand characteristics. It was especially evident that the demand levied against the aircraft MIC was significantly different from the demand pattern associated with the non-aircraft MICs. Demands against the aircraft MIC exhibited more of a constant Poisson pattern, whereas the demands against the other four MICs in the study showed more variability in demand, as associated with a compound Poisson process.

The relative performance of three MIC stockage policies were simulated and evaluated. The three were: 1) current 30/15 day stockage level and reorder point policy, 2) a 7/3.5 day policy, and 3) a hybrid lot-for-lot with safety factor policy partially based on studies by AFLMC.

The 30/15 policy provided the best support for the aircraft MIC. The modified lot-for-lot policy provided the best support for the non-aircraft MICs. The 7/3.5 policy had definitely the lowest fill rates, highest backorder-days and would probably have a detrimental impact upon MA's effectiveness and mission capability. The lot-for-lot policy consistently resulted in the fewest overall backorder-days of the three stockage polices.

In the simulation it was assumed that when the MIC needed to be replenished, D033 (DS) would have enough stocks on hand to replenish the MIC. This seemed a reasonable assumption at first, since, with few exceptions, if an item is on MIC detail, then it should be on D033 detail and DS should have stock. However, from analysis of the MIC intransit records, over 20 percent of the MIC intransits were for backorder releases, not request releases.

Research Conclusions

The importance of the differences in demand is that it supports the notion that different stockage policies and models may be appropriate for different product areas, or as a minimum, a model is most applicable if it can adjust to the differences in the observed demand and replenishment patterns.

The brief investigation into MIC intransit times was a necessary aside to the primary focus on MA demand patterns and stockage models. While it did provide an indication of a distribution form for the MIC simulation, it was also noted that most of the intransit times from DS to MA were larger than the maximum time allowable per AFM 67-1. If this is generally the case with all intransits, it has significant impact on any attempt to assure high support while minimizing inventory levels in MA. Considering the length and variability of the intransit times, a responsive realistic MIC stockage policy must account for actual intransit times.

MIC performance was simulated under various demand distribution and stockage polices. It became evident that a key to assuring MIC parts support was orienting the stockage technique to the expected number of units per request (lot size) and its variability. The orientation to "days worth of parts" and the DDR based current MIC stockage policy was not adequate for non-aircraft demands. The demands levied against the aircraft MIC were largely for quantities of one unit. With the lot size usually (60+ percent of demands) equal to one, the 30/15 "days" oriented stockage policy is adequate for most of the aircraft MIC stock levels. However, the non-aircraft MICs need a lot size oriented stockage policy.

Methodology Issues

The MIC simulations made an assumption that D033 always had enough stock on hand to fill a MIC replenishment request. This method of simulating MIC replenishments may overstate the ability of D033. The result is that the simulated fill rates may be more appropriately considered upper limits. It is also noted that the results of the simulations suppose perfect knowledge of the demands distributions and intransit times. Although actual responses would not be expected to occur exactly according to some theoretical distribution, the results provide a sound basis for relative comparison.

Actual demands were categorized by VMR, average days between requests, average units per request (UPR), and VMR of UPR. Some of the categories turned out not to have any occurrences; others had so few occurrences they were deemed to be insignificant for the purposes of this study. For instance, for MIC MDD, all the various outliers from the possible sets of demand parameters not simulated accounted for less than 1 percent of all the demands.

Suggestions for Follow-on Research

The actual demands studied covered 110 days. Considering the large percentage of NSNs with only one demand during 110 days, data collection and analysis of demands covering a longer time frame is suggested for follow-on research.

Regarding the observation that over 20 percent of MIC intransit releases were for backorder releases, such a high percentage would be expected for direct line issues or for items without D033 details, but by definition MIC intransit times are for items with MIC details, and in-turn D033 details. The ability of D033 to support MIC replenishments is recommended for follow-on research. Additionally, it was noted most of the sampled intransit times were larger than allowable as per AFM 67-1; actual intransit times, the factors that affect them, and necessary stockage model accommodations are recommended for follow-on research.

With the use of the MIC simulation model developed for this research, additional investigation could be directed to additional alternative MIC stockage policies under varying environments. For instance, the relative performance of alternative stockage policies under a surge environment could be investigated. The ability of D033 to support MA requests without intermediary MICs could also be explored.

The demand data and MIC simulation program could be used as part of a Depot Maintenance material decision support system. The data and variations of the simulation model could be used in analyzing and evaluating current and proposed material policies and procedures.

Additional recommendations for follow-on research include an exploration of MA demand distributions from the MRP perspective. Specifically

this could investigate the forecasting and planning for parts replacement variability at the bills of material level (rather than at the MIC or DS stock record level as was this research). Such knowledge and analysis could be used to improve material projections.

The observed variability of demands (combined with sporadic workloads) can have an undesired impacts on parts support. For items without D033 computed stock levels, D033 requires two or three demands (for XF/XB items) for the NSN to become eligible for D033 stock level computation (12:17-1). Over 50 percent of the NSNs studied had only one or two requests during the 110 days sampled. Many of these are undoubtedly recurring needs and critical to production. Follow-on research is recommended into whether the two/three criteria combined with D033 processing (and purging of data) adequately allows these parts to become eligible for stock level computation.

The frequency and variability of demand also raises concerns regarding MIC and D033 special levels. Special levels may be set up in D033 to support MA. When actual demands cause the computed level to equal or exceed the special level, the special level is automatically deleted (12:17-3). Research is recommended to examine if this logic is adequate in light of MA demand patterns. Hypothetically, a special level may be set up to support a parts requirement that occurs once every 200 to 360 days. Depending upon the actual demand, the level initially set up, and the computed stock level after the demand, the special level may be automatically deleted in lieu of the computed level. One hundred eighty days later the DDR and stock level have computed down to zero and the item becomes "eligible" for deletion from the D033 stock records, when actually, another demand is certain to occur.

Recommendations

The research has shown that the current MIC stockage policies and D033 safety levels equation are inadequate for many items due to the variability of demand. Based on the five MICs and 13,000+ demands studied, parts requests originating from aircraft repair were notably different from demand distributions originating from non-aircraft shops. Material support polices and procedures should reflect these differences. The current MIC orientation to "days worth" of stock does not adequately reflect actual parts demand patterns--it overstocks some items and understocks many others. Stockage policies and the levels in MICs (and D033) should at a minimum reflect the expected size of a request. MIC (and to some degree D033) stock levels based on material projections also need to reflect request sizes.

In addition, the following actions are recommended: 1) analyze parts demands for other types of end-items and other ALCs to verify findings apply across AFLC; 2) prototype the lot-for-lot MIC stockage technique at one or more of the MICs used in this research; and 3) (pending outcome of the analysis and prototype), perform a cost-benefits analysis for the possible inclusion of expected request size logic within the Depot Maintenance Exchangeables Production System (EPS/G402A), the Depot Maintenance Management Information System (DMMIS), and the Stock Control and Distribution System (SC&D).

Appendix A: Sample of D033 "TVA" Report

CA MTPFEM DEPOT MAINTENANCE MATERIAL SUPPORT AS OF 88181 OCALC A-D033.-TVA-TT-GTV PAGE 77

	DEMAND ACCOMMODATION AND OBJECTIVES				DEMAND SATISFACTION AND % TOTAL FILL OBJECTIVES							LESS THAN 100% SUPPORT	
	NUMBER DEMANDS	NUMBER MATCHED	% MATCH	% MATCH OBJ	NUMBER TOTAL FILL	% TOTAL FILL	% TOTAL FILL OBJ	# PARTIAL FILL	% PARTIAL FILL	# ZERO FILL	% ZERO FILL	# LESS 100%	% LESS 100%
					DIRECT MATERIAL SUPPORT								
MIC	205	171	83.4%	85%	132	77.1%	95%	25	14.6%	14	8.1%	73	35.6%
DS	74	41	55.4%	85%	41	100.0%	95%					33	44.6%
TOTAL	206	179	86.8%	85%	173	96.6%	95%					33	16.0%
FILLED FROM EXCESS					32							(32)	
FILL RATE	206				205	99.5%						1	[illegible]
					INDIRECT MATERIAL SUPPORT								
U8100 BENCH STOCK	2	1	50.0%	85%			95%			1	100.0%	2	100.0%
FILL RATE	2											2	100.0%

Figure 10. Sample of D033 "TVA" Report

Appendix B: Sample of Demand Data

(Excerpt of sampled data elements for MIC MDD)

MIC	DOC ID	ISS QTY	HIST STK NR	MIC STK NR	PROD NBR	ADV CD	PROC DATE
MDD	D7	1	5945000806387	5945000806387	72373A	2C	88116
MDD	D7	1		5945000806387	72373A		88116
MDD	D7	5	5945000812026		72473A		88127
MDD	D7	1	5945000873774	5945000873774	26713A		88130
MDD	D7	1		5945000873774	26713A		88054
MDD	D7	1		5945000873774	26713A		88130
MDD	D7	1		5945000873774	26713A		88125
MDD	D7	1		5945000873774	26713A		88042
MDD	D7	2		5945000873774	26713A		88103
MDD	D7	10	5945000889833		75034A		88119
MDD	D7	10	5945001041186	5945001041186	75034A		88119
MDD	D7	1	5945001564040	5945001564040	91533A	2C	88082
MDD	D7	8		5945001564040	91533A	2C	88103
MDD	D7	2		5945001564040	16503A	2C	88082
MDD	D7	2		5945001564040	91533A	2C	88041
MDD	D7	1		5945001564040	91533A	2C	88117
MDD	D7	10	5945001683801	5945001683801	72755A	2C	88088
MDD	D7	4	5945001706307		91907A		88054
MDD	D7	1	5945001734884	5945001734884	62371A		88075
MDD	D7	1		5945001734884	62371A		88063
MDD	D7	2	5945002357405NT	5945002357405NT	96041A		88099
MDD	D7	1	5945002447648	5945002447648	62371A		88097
MDD	D7	2		5945002447648	62371A		88036
MDD	D7	3	5945002582795	5945002582795	91997A		88069
MDD	D7	5		5945002582795	91997A		88089
MDD	D7	3	5945003706279	5945003706279	91997A	2C	88131
MDD	D7	1		5945003706279	91997A		88075
MDD	D7	5		5945003706279	91997A	2C	88048
MDD	D7	1		5945003706279	91997A		88048
MDD	D7	4		5945003706279	91997A	2C	88075
MDD	D7	4		5945003706279	91997A	2C	88119
MDD	D7	1	5945003721786	5945003721786	69403A		88141
MDD	D7	4	5945004219588	5945004219588	18978A		88116
MDD	D7	1	5945004279427		70374A		88098
MDD	D7	2	5945004359486	5945004359486	72087A		88139
MDD	D7	4		5945004359486	72087A		88139
MDD	D7	4	5945004488817		72087A		88139
MDD	D7	10	5945004825283	5945004825283	75034A		88131

DOC ID "D7" stands for issue request;
HIST STK NR stands for NSN requested;
MIC STK NR stands for NSN of MIC's detail, if one matches;
ADV CD stands for advice code: 2C for "Fill or Kill" request;
PROD NBR stands for production number intended for material;
PROC DATE represents date request was submitted through G402A.

Appendix C: TANDEM ENFORM Interrogation Routine to Extract Request Data from ADS G402A Data Base

```
?DICTIONARY $DATA.QRADDL
?ASSIGN QRM1COTH,$DATA15.QRADBA.QRM1COTH,SHARED
?ASSIGN QRMMICD,$DATA10.QRADBA.QRMMICD,SHARED
?OUT \LAB.$S.#HISTF
OPEN QRM1COTH QRMMICD;
LINK COMP-NSN OF QRM1COTH TO OPTIONAL
     COMP-NSN OF MIC-NSN OF QRMMICD;

LIST
       MIC                 OF QRM1COTH  HEADING   "/MIC",
       DOC-ID              OF QRM1COTH  HEADING   "DOC/ID",
       QTY                 OF QRM1COTH  HEADING   "ISS/QTY",
  BY   COMP-NSN            OF QRM1COTH  HEADING   "/HIST STK NR",
       COMP-NSN            OF QRMMICD   HEADING   "/MIC STK NR",
       NSN-SOURCE          OF QRMMICD   HEADING   "SOURCE",
       PRODUCTION-NBR      OF QRM1COTH  HEADING   "PROD/NBR",
       ADV-CD              OF QRM1COTH  HEADING   "ADV/CD",
       COST-CD             OF QRM1COTH  HEADING   "COST/CD",
       PROC-DATE           OF QRM1COTH  HEADING   "PROC/DATE",
       TYP-TRAN-HIST-CD    OF QRM1COTH  HEADING   "TYP/TRAN",
WHERE (MIC OF QRM1COTH = "MCC") AND (MIC OF QRMMICD = "MCC") AND
      (COST-CD OF QRM1COTH = "A" OR COST-CD OF QRM1COTH = "R" ) AND
      (ADV-CD OF QRM1COTH = " " OR ADV-CD OF QRM1COTH = "2C") AND
      (DOC-ID-2 OF QRM1COTH = "D7" ) AND (PDN-PFX OF CONTROL-NBR = "0"
      THRU "9") AND (TYP-TRAN-HIST-CD = "I") AND (PROC-DATE EQUAL
      "88002" THRU "88144");

CLOSE QRM1COTH QRMMICD;
```

Appendix D: BASS Program Listings
(For MIC Demand Analysis)

```
RUN CREATE > MICNSN;
 LENGTH MIC $ 3 NSN $ 15;
 INFILE C:\DATA\MICBASS.DAT;
 INPUT  MIC $ 1-3 QTY 5-9 NSN $ 15-29 DATE 31-35;
RUN CREATE > MICSUM;
  SETIN MICNSN;
  BY NSN DATE;
  VAR NSN CRD DDR N NDAYS V_DDR VMR V_D_QTY V_R_QTY AVE_R AVE_DBR MIC;
RETAIN CRD CRDSQ N V_DDR NDAYS V_D_QTY V_R_QTY QTY_Q VMR CRD_Q CRDSQ_Q
DDR AVE_R AVE_DBR;
FORMAT CRD 4.0 CRDSQ 8.0 N 3.0 V_DDR 8.3 NDAYS 3.0 V_D_QTY 7.2 V_R_QTY
7.2;
FORMAT QTY_Q 4.0 VMR 7.3 CRD_Q 4.0 DDR 6.3 AVE_R 7.2 AVE_DBR 7.2;
IF _OBS_ = 1 THEN
DO;
  CRD = 0;
  CRDSQ = 0;
  V_DDR = 0;
  N = 0;
  QTY_Q = 0;
  CRD_Q = 0;
  CRDSQ_Q = 0;
  NDAYS = 0;
  V_D_QTY = 0;
  V_R_QTY = 0;
END;
CRD = CRD + QTY;
CRDSQ = CRDSQ + QTY * QTY;
N = N + 1;
IF _LAST_(2) THEN
  DO;
   QTY_Q = QTY_Q + QTY;
   CRD_Q = CRD_Q + QTY_Q;
   NDAYS = NDAYS + 1;
   CRDSQ_Q = CRDSQ_Q + QTY_Q * QTY_Q;
   QTY_Q = 0;
  END;
 ELSE QTY_Q = QTY_Q + QTY;
IF _LAST_(1) THEN
 DO;
  DDR = CRD / 110;
  AVE_R = CRD / N;
  AVE_DBR = 110 / N;
  V_DDR = ( CRDSQ_Q - ( CRD_Q * CRD_Q ) / 110 ) / 110;
  V_D_QTY = ( CRDSQ_Q - ( CRD_Q * CRD_Q ) / NDAYS ) / NDAYS;
  V_R_QTY = ( CRDSQ - ( CRD * CRD ) / N ) / N;
  VMR = V_DDR / DDR;
  V_DDR = 0;
```

```
  V_D_QTY = 0;
  V_R_QTY = 0;
  CRD = 0;
  CRDSQ = 0;
  N = 0;
  NDAYS = 0;
  CRDSQ_Q = 0;
  QTY_Q = 0;
  CRD_Q =0;
 END;
RUN AVERAGE < MICSUM MEAN STD MIN MAX MAXDEC=3 SKEW KURT;
  VAR DDR VMR NDAYS N CRD AVE_R AVE_DBR V_D_QTY V_R_QTY;
RUN CREATE < MICSUM > TEMP1;
  VAR VMR_GRP FSC;
  FORMAT VMR_GRP 3.0 FSC 2.0;
  IF VMR <= 4 THEN VMR_GRP = 1;
  ELSE IF VMR <= 10 THEN VMR_GRP = 2;
  ELSE IF VMR <= 30 THEN VMR_GRP = 3;
  ELSE IF VMR <= 40 THEN VMR_GRP = 4;
  ELSE IF VMR <= 100 THEN VMR_GRP = 5;
  ELSE IF VMR > 100 THEN VMR_GRP = 6;
  FSC = CHARTONUM(MID(NSN,1,2));

RUN CHART < TEMP1 VBAR ;
  VAR VMR_GRP;
RUN EDA < MICSUM EXTREMES ID=NSN;
  VAR AVE_R AVE_DBR VMR;

{SUMMARY OF N's ... BY "CONSTANT-POISSON & POISSON-POISSON"}
RUN CREATE < MICSUM > TEMPSUM;
 LENGTH DIST_Q $ 5;
 VAR  N  DBR_GRP DIST_Q;
 FORMAT  VMR_R 8.3 DBR_GRP 3.0;
{ TITLE2 *** CROSSTABS OF REQUESTS DURING TIMEFRAME ***;}
 TITLE2 *** CROSSTABS OF LINE ITEMS WITH REQUESTS DURING TIMEFRAME ***;
 LABEL DIST_Q = 'DIST AND AVE # IN RQSTS, CP 2 ==> CONST POISSON, AVE #
= 2';
 LABEL DBR_GRP = 'AVE DAYS/RQST GRP CODE = 110(DAYS)/(# RQSTS * 3.5 DAY
CYCLE)';
 VMR_R = V_R_QTY / AVE_R; {VMR OF REQUEST QUANTITY, NOT DAILY DEMAND
RATE!}
{ CROSS TAB MULTIPLE N REQUESTS WHERE VMR_R >= 0.25}
 IF ( N > 1.5 AND VMR_R >= 0.25 ) THEN
  DO;
   IF VMR >= 150 THEN DELETE; {DON'T BIAS BY OUTLIERS}
   IF AVE_DBR <= 3.5 THEN DBR_GRP = 1;
    ELSE IF AVE_DBR <= 7    THEN DBR_GRP = 2;
    ELSE IF AVE_DBR <= 10.5 THEN DBR_GRP = 3;
    ELSE IF AVE_DBR <= 14   THEN DBR_GRP = 4;
    ELSE IF AVE_DBR <= 17.5 THEN DBR_GRP = 5;
    ELSE IF AVE_DBR <= 21   THEN DBR_GRP = 6;
    ELSE IF AVE_DBR <= 24.5 THEN DBR_GRP = 7;
    ELSE IF AVE_DBR <= 28   THEN DBR_GRP = 8;
```

```
      ELSE IF AVE_DBR <= 38.5 THEN DBR_GRP = 11;
      ELSE IF AVE_DBR <= 56   THEN DBR_GRP = 16;
      ELSE IF AVE_DBR <= 112  THEN DBR_GRP = 32;
     IF AVE_R <= 1.2 THEN DELETE;{IF <=1.2, TOO SMALL POP FOR PP}
      ELSE IF AVE_R <= 4  THEN DIST_Q = 'PP  2';
      ELSE IF AVE_R <= 10 THEN DIST_Q = 'PP  7';
      ELSE IF AVE_R <= 30 THEN DIST_Q = 'PP 20';
           ELSE DELETE;
   END;
  IF ( N > 1.5 AND VMR_R < 0.25) THEN
   DO;
     IF AVE_DBR <= 3.5 THEN DBR_GRP = 1;
      ELSE IF AVE_DBR <= 7    THEN DBR_GRP = 2;
      ELSE IF AVE_DBR <= 10.5 THEN DBR_GRP = 3;
      ELSE IF AVE_DBR <= 14   THEN DBR_GRP = 4;
      ELSE IF AVE_DBR <= 17.5 THEN DBR_GRP = 5;
      ELSE IF AVE_DBR <= 21   THEN DBR_GRP = 6;
      ELSE IF AVE_DBR <= 24.5 THEN DBR_GRP = 7;
      ELSE IF AVE_DBR <= 28   THEN DBR_GRP = 8;
      ELSE IF AVE_DBR <= 38.5 THEN DBR_GRP = 11;
      ELSE IF AVE_DBR <= 56   THEN DBR_GRP = 16;
      ELSE IF AVE_DBR <= 112  THEN DBR_GRP = 32;
     IF AVE_R <= 1.2 THEN DIST_Q = 'CP  1';
      ELSE IF AVE_R <= 4  THEN DIST_Q = 'CP  2';
      ELSE IF AVE_R <= 10 THEN DIST_Q = 'CP  7';
      ELSE IF AVE_R > 10 THEN DELETE;
     IF VMR >= 250 THEN DELETE;
   END;
IF N <= 1.5 THEN {WHAT TO DO WITH SINGLE REQUESTS...}
    DO;
       DBR_GRP = 32;
       IF VMR >= 250 THEN DELETE; {DON'T BIAS BY OUTLIERS}
       RV = RANDOM_UNIFORM(363791);
       IF AVE_R <= 1.2 THEN DIST_Q = 'CP  1';
       ELSE IF ( AVE_R <=  4 AND RV <= .575 ) THEN DIST_Q = 'CP  2';
       ELSE IF ( AVE_R <=  4 AND RV >  .575 ) THEN DIST_Q = 'PP  2';
       ELSE IF ( AVE_R <= 10 AND RV <= .151 ) THEN DIST_Q = 'CP  7';
       ELSE IF ( AVE_R <= 10 AND RV >  .151 ) THEN DIST_Q = 'PP  7';
          { REFERENCE C:\DATA\...\CP_VS_PP.WKZ FOR COMPUTATIONS}
       ELSE IF AVE_R <= 30 THEN DIST_Q = 'PP 20';
    END;
IF N <= 1.5 AND AVE_R > 30 THEN DELETE;

{FOR USE WITH LINE ITEM LEVEL DISTRIBUTION}
RUN COUNT < TEMPSUM;
  TABLES DIST_Q*DBR_GRP;
{FOR USE WITH REQUEST LEVEL DISTRIBUTION}
 RUN COUNT < TEMPSUM;
  TABLES DIST_Q*DBR_GRP;
  WEIGHT N;
  TITLE2 *** CROSSTABS OF REQUESTS DURING TIMEFRAME ***;
RUN ;
```

Appendix E: MIC Demand Patterns

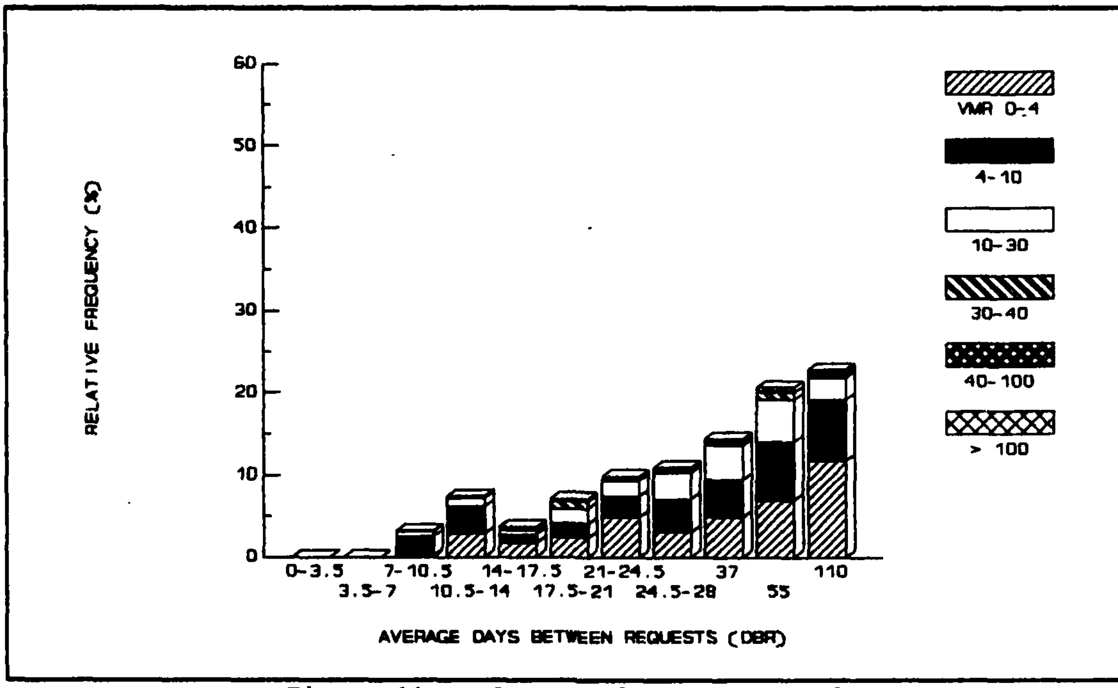

Figure 11. MFF Demands at NSN Level

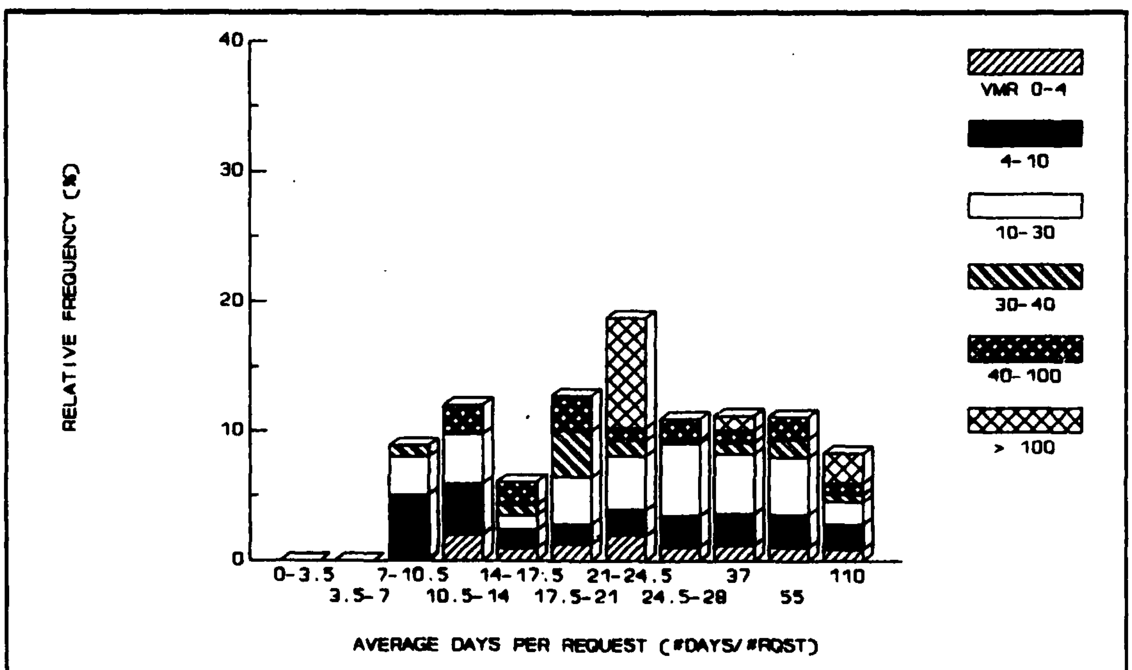

Figure 12. MFF Demands Weighted by Units

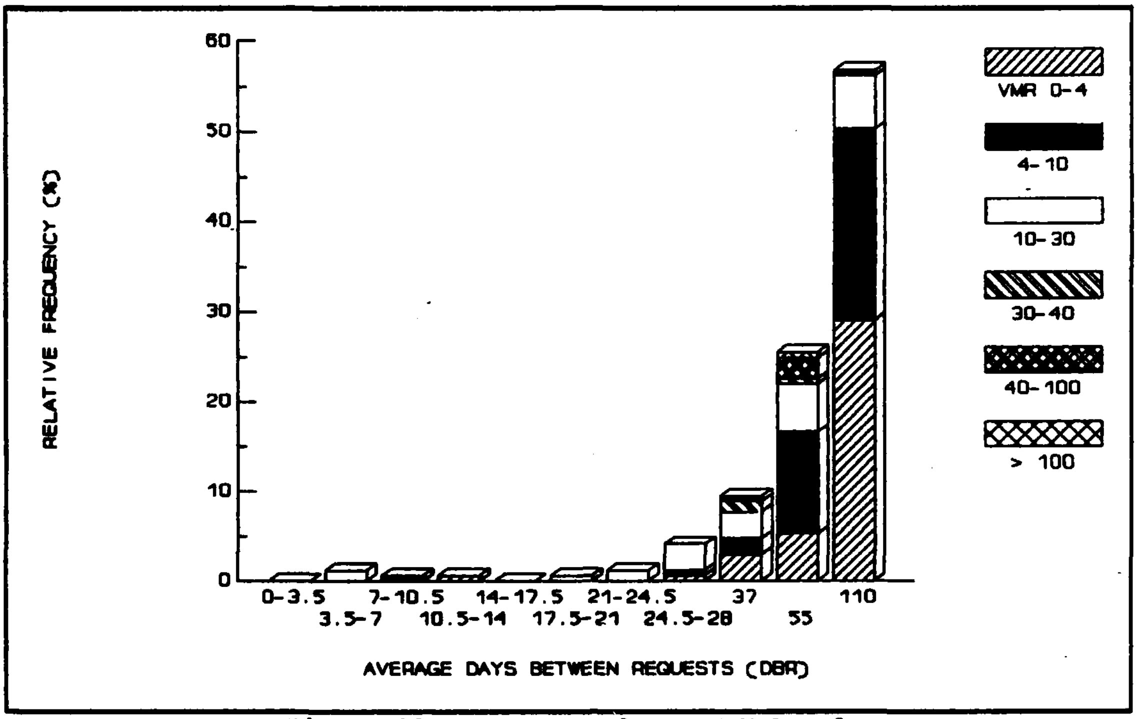

Figure 13. MGG Demands at NSN Level

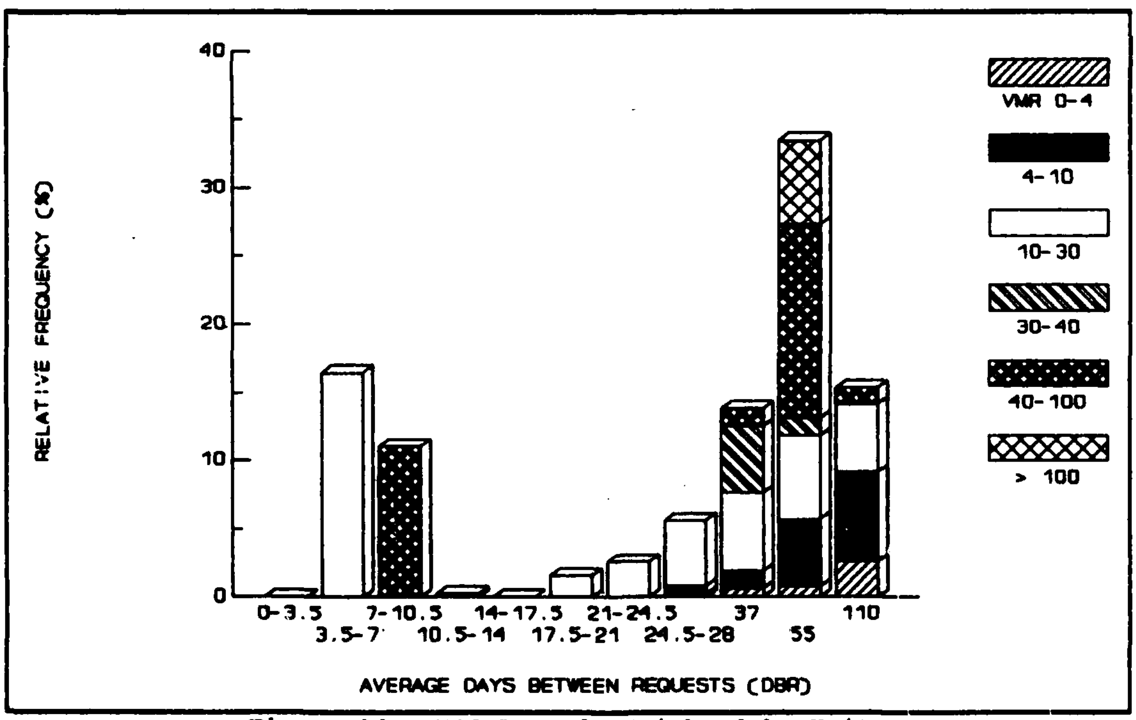

Figure 14. MGG Demands Weighted by Units

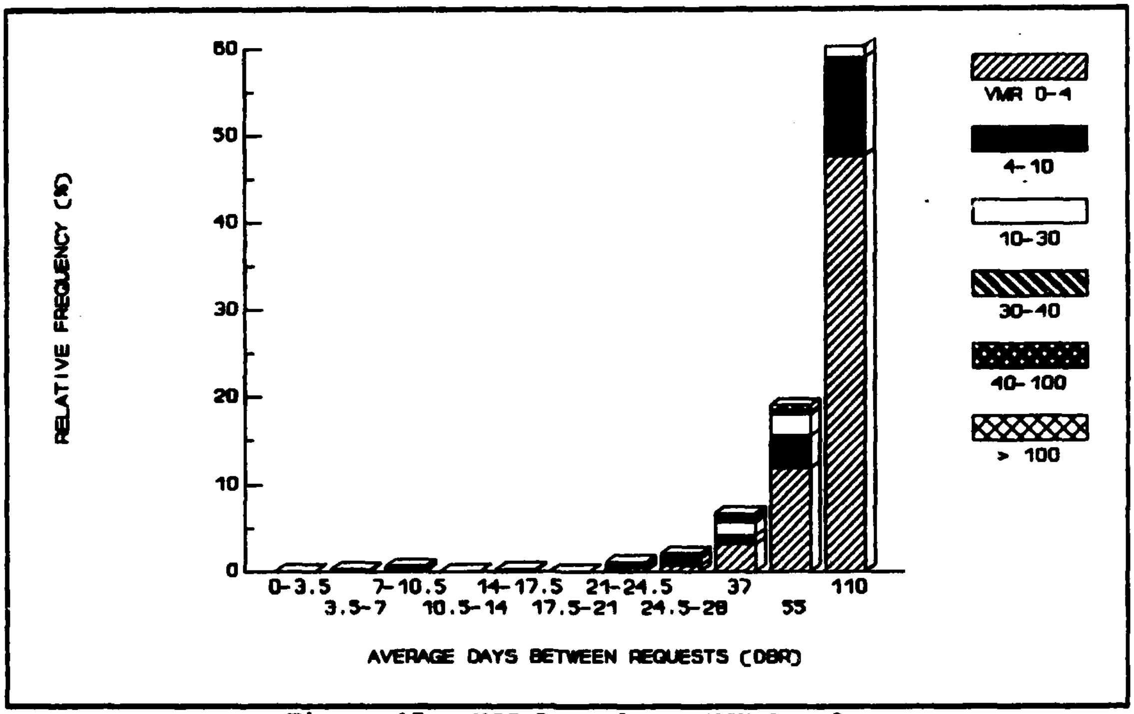

Figure 15. MJJ Demands at NSN Level

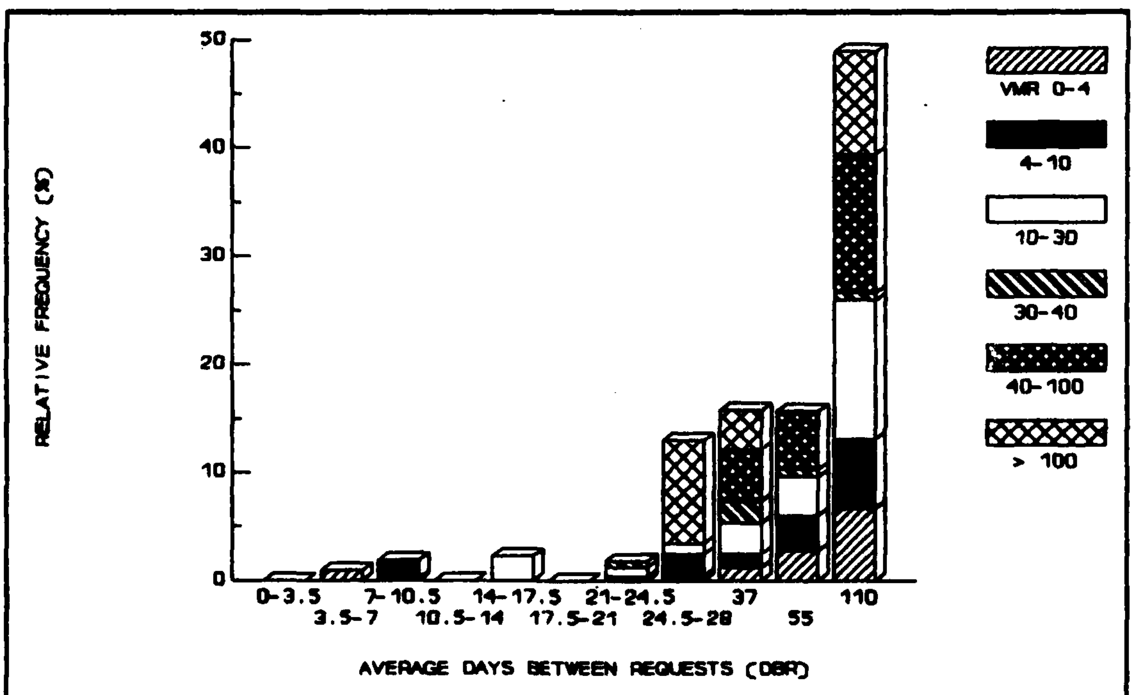

Figure 16. MJJ Demands Weighted by Units

Appendix F: Crosstabed Demand Data for MICs MFF, MGG, MJJ

%	3	5	9	12	16	18	22	28	37	55	110	TOTAL
	MIC MDD					DBR						
CP1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.3	0.9	1.4
CP2	0.0	0.0	0.0	5.7	2.1	1.1	4.6	1.7	2.4	2.5	1.3	21.4
CP7	0.0	0.0	0.0	2.4	0.6	0.2	0.1	0.6	0.6	1.8	0.3	6.6
PP2	0.0	0.0	1.7	4.3	1.5	4.6	3.9	3.7	3.2	2.0	1.0	25.9
PP7	0.0	0.0	7.3	3.7	1.7	2.5	2.4	3.2	3.5	2.4	1.8	28.4
P20	0.0	0.0	2.3	1.6	0.8	2.9	1.9	2.6	2.0	1.6	0.7	16.4
TOTAL	0.0	0.0	11.3	17.6	6.7	11.3	13.1	11.8	11.7	10.6	6.1	100

n = 3362 REQUESTS

%	3	5	9	12	16	18	22	28	37	55	110	TOTAL
	MIC MGG					DBR						
CP1	0.0	0.0	0.0	2.5	0.0	0.0	0.0	0.0	0.0	0.6	5.1	8.3
CP2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	3.8	5.1	5.1	15.3
CP7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	1.0	3.8	2.5	8.6
PP2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	3.8	5.4	10.2
PP7	0.0	0.0	0.0	0.0	0.0	1.9	1.6	5.1	2.9	5.7	8.9	26.1
P20	0.0	11.5	4.8	0.0	0.0	0.0	1.6	1.3	4.8	4.5	3.2	31.5
TOTAL	0.0	11.5	4.8	2.5	0.0	1.9	3.2	8.9	13.4	23.6	30.3	100

n = 314 REQUESTS

%	3	5	9	12	16	18	22	28	37	55	110	TOTAL
	MIC MJJ					DBR						
CP1	0.0	0.0	1.5	0.0	0.0	0.0	1.4	0.0	2.5	8.4	19.4	33.2
CP2	0.0	0.0	0.0	0.0	0.0	0.0	0.7	1.1	3.8	8.7	6.3	20.6
CP7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	1.3	2.0	1.5	5.9
PP2	0.0	3.1	1.7	0.0	0.0	0.0	0.0	1.1	0.8	1.4	6.6	14.7
PP7	0.0	0.0	1.5	0.0	0.0	0.0	1.4	1.1	3.0	3.6	6.0	16.7
P20	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.8	1.1	5.9	8.8
TOTAL	0.0	3.1	4.8	0.0	1.0	0.0	3.5	4.5	12.2	25.2	45.7	100

n = 713 REQUESTS

Appendix G: Sample of DS-MIC Intransit Data

DOC ID	MIC	NSN	UI	QTY	DOC NR	AC SF	T R	DATE	TIME
INT	MSS	5330012485451AQ	EA	67	MKMMSS70743104		R	88170	172347
INT	MSS	5330012485451AQ	EA	67		CL	I	88173	080541
INT	MSS	1420011112149GF	EA	1	MKMMSS72241847	CL	I	88154	073805
INT	MSS	5905001391375JB	EA	3	MKMMSS72252576		R	88162	171711
INT	MSS	5905001391375JB	EA	3		CL	I	88176	122712
INT	MSS	4710002287643BF	EA	3	MKMMSS80491739	CL	I	88153	130507
INT	MSS	5962012521486	EA	1	MKMMSS80684170		R	88172	190907
INT	MSS	5962012521486	EA	1		CL	I	88173	142357
INT	MSS	1430003980384BF	EA	2	MKMMSS81042380		R	88165	192651
INT	MSS	1430003980384BF	EA	2		CL	I	88169	124710
INT	MSS	5995001309164BF	EA	1	MKMMSS81312544		R	88167	225859
INT	MSS	5995001309164BF	EA	1			O	88168	101723
INT	MSS	5961001051987	EA	9	MKMMSS81332566		R	88169	131806
INT	MSS	5961001051987	EA	9		CL	I	88172	142410
INT	MSS	6670011784749	EA	3			R	88155	214955
INT	MSS	6670011784749	EA	3		CL	I	88159	105718
INT	MSS	6670011784743	EA	8	MKMMSS81402092	CL	I	88153	130444
INT	MSS	1420001853505CJ	EA	1	MKMMSS81451233	CL	I	88154	073340
INT	MSS	1420003500959CJ	EA	1	MKMMSS81451239		R	88166	104033
INT	MSS	1420003500959CJ	EA	1		CL	I	88169	124437
INT	MSS	5962011784364	EA	5	MKMMSS81471099		R	88153	090815
INT	MSS	5962011784364	EA	5		CL	I	88154	081255
INT	MSS	5962011237453	EA	5	MKMMSS81471514	CL	I	88154	073530
INT	MSS	1430003293133BF	EA	6	MKMMSS81471515	CL	I	88154	073442
INT	MSS	5961007643161	EA	4	MKMMSS81471521	CL	I	88154	073356
INT	MSS	5990000558429	EA	10	MKMMSS81471526	CL	I	88154	073715
INT	MSS	5905000588616	EA	3	MKMMSS81471528	CL	I	88154	073747
INT	MSS	5962001470790	EA	4	MKMMSS81471672	CL	I	88154	073615
INT	MSS	5945001538761	EA	3	MKMMSS81472053	CL	I	88154	073600
INT	MSS	1430009972074BF	EA	3	MKMMSS81472056	CL	I	88154	073514
INT	MSS	1430000170561BF	EA	2	MKMMSS81472058	CL	I	88154	073732
INT	MSS	1430002457948BF	EA	3	MKMMSS81472060	CL	I	88154	073306
INT	MSS	5961008254623BF	EA	2	MKMMSS81472085	CL	I	88154	073645
INT	MSS	5935000522668	EA	10	MKMMSS81481470	CL	I	88154	073212
INT	MSS	5935000522667	EA	6	MKMMSS81481472		R	88158	232439
INT	MSS	5935000522667	EA	6		CL	I	88162	100733
INT	MSS	5935000502152	EA	4	MKMMSS81481473	CL	I	88154	073411

Appendix H: TANDEM ENFORM Interrogation Routine to Extract Intransit Data from ADS G402A

```
?DICTIONARY  $DATA.QRADDL
?ASSIGN QRM1COTH,$DATA15.QRADBA.QRM1COTH,SHARED
?OUT \LAB.$S.#WANE
OPEN QRM1COTH;
LIST
      DOC-ID                OF QRM1COTH  HEADING "DOC/ID",
      MIC                   OF QRM1COTH  HEADING "MIC",
      TYP-TRANS-CD          OF QRM1COTH  HEADING "T/T",
      STKNBR                OF QRM1COTH  HEADING "NSN",
      UNIT-OF-ISS           OF QRM1COTH  HEADING "UI",
      QTY                   OF QRM1COTH  HEADING "QTY",
BY    DOC-NBR               OF QRM1COTH  HEADING "DOC NR",
      DEMAND-SFX            OF QRM1COTH  HEADING "D/S",
      INT-BIN-LOC           OF QRM1COTH  HEADING "IBL",
      PRI-CD                OF QRM1COTH  HEADING "PRI",
      JON-SFX               OF QRM1COTH  HEADING "JON/SFX",
      ADV-CD                OF QRM1COTH  HEADING "ADV/CD",
      ACT-SFX               OF QRM1COTH  HEADING "AC/SF",
      TYP-TRAN-HIST-CD      OF QRM1COTH  HEADING "T/R",
      PROC-DATE-2           OF QRM1COTH  HEADING "PDATE",
      PROC-TIME-2           OF QRM1COTH  HEADING "PTIME",
WHERE (MIC OF QRM1COTH = "MFF") AND (DOC-ID OF QRM1COTH = "INT")
AND (PROC-DATE-2 = "88153" THRU "88182");
CLOSE QRM1COTH;
```

Appendix I: P&A AID Program Output for Sample Intransit Data
(Extract from output)

AID
C COPYRIGHT 1981 BY PRITSKER AND ASSOCIATES, INC.

NUMBER OF OBSERVATIONS : 123

INPUT FORMAT : (1X,F7.4)

```
************************
*                      *
*    ORDERED DATA      *
*                      *
************************
```

0.919	0.920	0.921	0.961	1.102	1.494	1.561
1.844	1.844	1.845	1.847	1.929	2.119	2.558
2.612	2.713	2.860	2.867	2.867	2.867	2.868
2.871	2.904	2.913	2.914	2.915	2.916	2.918
2.925	2.928	2.960	2.965	2.967	2.967	2.967
2.968	2.968	2.971	2.971	2.972	3.018	3.046
3.086	3.447	3.547	3.723	3.785	3.869	3.870
3.873	3.874	3.876	3.876	3.903	3.908	3.908
3.922	3.924	3.926	4.027	4.031	4.615	4.623
4.694	4.821	4.826	4.828	4.851	5.602	5.803
5.810	5.842	5.899	6.006	6.006	6.007	6.008
6.009	6.244	6.245	6.815	6.817	6.817	6.820
6.821	6.821	6.822	6.823	6.945	7.017	7.020
7.112	7.808	7.814	7.817	7.817	7.826	7.829
7.830	7.831	7.888	7.922	8.794	8.910	8.913
9.237	9.623	10.615	10.615	10.619	10.619	10.619
10.619	10.620	10.817	10.819	10.826	10.827	10.828
10.828	10.830	10.831	10.831			

MEAN-------------------------------- 5.357

STANDARD DEVIATION------------------ 2.933

MINIMUM----------------------------- 0.919

MAXIMUM----------------------------- 10.831

```
*************************************
*                                   *
*     KOLMOGOROV-SMIRNOV TEST       *
*                                   *
*************************************

               ******************
               *                *
               *   HYPOTHESIS   *
               *                *
               ******************

DISTRIBUTION-------------------------    LOGNORMAL

MEAN---------------------------------        5.466

STANDARD DEVIATION-------------------        3.688

ALPHA--------------------------------        4.531

BETA---------------------------------        0.613

             ***********************
             *                     *
             *   TEST PARAMETERS   *
             *                     *
             ***********************

SAMPLE SIZE-----------------------------       123

LEVEL OF SIGNIFICANCE-------------------     0.050

CRITICAL VALUE--------------------------     0.123

TEST STATISTIC--------------------------     0.097

        -----     ACCEPT HYPOTHESIS     -----
```

Appendix J: Performance of MIC Stockage Policies

Table 14. Performance of 30/15 MIC Stockage Policy

LIFR / UFR / On-Hand / BO-Days	(AVERAGE NUMBER OF DAYS BETWEEN REQUESTS)										
	3	5.25	8.75	12.25	15.7	18.3	22	27.5	36.6	55	110
	0.99	0.99	0.99	0.99	0.97	0.96	0.95	0.94	0.96	0.94	0.73
CP1	0.99	0.99	0.99	0.99	0.97	0.96	0.95	0.95	0.96	0.94	0.79
	7.3	4.7	3.2	2.6	2.3	2.0	1.8	1.6	1.4	1.0	1.1
	0.6	1.2	1.2	0.1	1.2	1.5	1.6	1.4	1.6	1.4	6.8
	0.99	0.97	0.92	0.91	0.86	0.86	0.82	0.78	0.64	0.56	0.08
CP2	0.99	0.99	0.95	0.94	0.92	0.90	0.90	0.85	0.81	0.78	0.46
	20.6	12.5	8.0	5.9	5.1	4.6	4.1	3.5	2.8	2.3	1.4
	3.7	3.7	14.7	9.4	10.8	14.8	13.3	19.4	18.1	23.0	23.1
	0.99	0.98	0.90	0.87	0.84	0.79	0.71	0.58	0.47	0.11	0.00
CP7	0.99	0.99	0.94	0.93	0.91	0.89	0.86	0.79	0.75	0.64	0.38
	40.2	24.3	15.5	11.4	9.3	8.6	7.5	6.1	5.1	3.8	2.3
	10.6	7.7	31.3	28.8	29.6	32.9	39.9	48.4	58.0	75.0	54.9
	0.99	0.96	0.91	0.89	0.84	0.82	0.78	0.71	0.66	0.62	0.47
PP2	0.99	0.97	0.92	0.91	0.87	0.84	0.84	0.77	0.74	0.69	0.62
	18.2	11.1	7.3	5.6	4.7	4.2	3.6	3.0	2.7	2.2	1.4
	5.8	15.5	18.1	19.9	24.0	24.4	24.1	26.8	35.4	34.5	16.9
	0.99	0.96	0.91	0.85	0.81	0.78	0.72	0.61	0.49	0.40	0.19
PP7	0.99	0.97	0.94	0.90	0.88	0.84	0.83	0.76	0.71	0.64	0.50
	40.2	24.0	15.5	11.7	9.8	8.7	7.5	6.0	5.1	4.0	2.5
	10.2	23.6	30.1	38.3	47.9	54.7	55.6	57.7	71.4	76.2	45.6
	0.99	0.96	0.90	0.87	0.75	0.71	0.65	0.51	0.38	0.15	0.04
PP	0.99	0.98	0.94	0.92	0.88	0.85	0.83	0.75	0.70	0.61	0.37
20	111.2	65.7	42.6	30.3	24.9	23.4	20.3	16.7	14.0	10.1	6.0
	25.4	43.5	95.7	95.7	107.6	145.5	145.2	179.3	181.7	215.1	165.1

CP = Constant Poisson   PP = Compound Poisson

The simulated results of a 30 day stockage objective and 15 day reorder point policy are shown in Table 14. The simulation results for the MIC 7/3.5 stockage policy are provided in Table 15.

Table 15. Performance of 7/3.5 MIC Stockage Policy

LIFR / UFR / On-Hand / BO-Days	(AVERAGE NUMBER OF DAYS BETWEEN REQUESTS) 3	5.25	8.75	12.25	15.71	18.33	22	27.5	36.66	55	110
	0.79	0.78	0.67	0.69	0.75	0.79	0.79	0.85	0.89	0.93	0.92
CP1	0.79	0.78	0.67	0.69	0.75	0.79	0.79	0.85	0.89	0.93	0.92
	1.5	1.2	0.8	0.7	0.8	0.8	0.8	0.8	0.9	0.9	1.0
	37.1	29.5	36.6	24.5	12.5	10.3	9.0	5.3	3.2	1.7	0.2
	0.52	0.48	0.48	0.25	0.02	0.01	0.00	0.00	0.00	0.00	0.00
CP2	0.62	0.63	0.57	0.55	0.48	0.47	0.45	0.40	0.34	0.31	0.31
	3.1	2.6	1.9	1.6	1.4	1.4	1.3	1.2	1.0	0.9	1.0
	290.3	179.6	147.6	140.2	141.4	125.0	117.3	110.3	103.3	68.7	30.9
	0.46	0.42	0.28	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CP7	0.57	0.61	0.52	0.47	0.43	0.40	0.37	0.32	0.27	0.25	0.17
	5.5	4.8	3.3	2.8	2.5	2.3	2.2	2.0	1.6	1.4	1.1
	735.5	402.1	371.9	338.9	315.0	301.6	285.4	246.4	210.2	166.3	78.1
	0.56	0.54	0.49	0.41	0.40	0.39	0.35	0.34	0.38	0.33	0.40
PP2	0.60	0.59	0.54	0.51	0.48	0.46	0.44	0.40	0.45	0.44	0.55
	3.0	2.3	1.8	1.6	1.4	1.3	1.2	1.0	1.0	0.9	1.0
	306.8	221.4	175.1	145.3	127.0	128.9	109.0	96.7	76.8	48.8	17.8
	0.49	0.45	0.33	0.22	0.19	0.15	0.15	0.11	0.09	0.08	0.06
PP7	0.57	0.57	0.49	0.44	0.41	0.39	0.36	0.33	0.31	0.28	0.25
	6.0	4.6	3.4	2.8	2.5	2.3	2.1	1.8	1.7	1.4	1.1
	752.0	486.3	444.9	357.2	342.8	323.4	288.5	217.9	199.6	154.8	64.5
	0.44	0.41	0.21	0.08	0.03	0.03	0.01	0.00	0.00	0.00	0.00
PP	0.56	0.56	0.48	0.44	0.38	0.34	0.30	0.26	0.20	0.18	0.12
20	15.2	12.2	8.9	7.2	6.1	5.7	4.9	4.2	3.6	2.9	1.8
	2120	1410	1232	1096	1022	949	867	705	605	470	238

CP = Constant Poisson PP = Compound Poisson

The tables consists of cells with four performance measures (rows) for each set of the parameters simulated. For instance, the cell in the top left corner represents the performance measures when the simulation was run using a constant Poisson (CP) distribution with arrivals being exponentially distributed having a mean of 3 days between requests and a constant order quantity of one. The top line in the cell represents the grand mean "observed" line item fill rate (LIFR). The second line in the cell represents the grand mean

observed unit (level) fill rate (UFR). The second line is the average on-hand level in the MIC (O/H), and the last line in the cell is the avergae number of backorder-days per year. The simulation results for the MIC lot-for-lot stockage policy are in Table 16.

Table 16. Performance of Lot-for-Lot MIC Stockage Policy

LIFR UFR On-Hand BO-Days	(AVERAGE NUMBER OF DAYS BETWEEN REQUESTS) 3	5.25	8.75	12.25	15.71	18.33	22	27.5	36.66	55	110
	0.96	0.93	0.88	0.88	0.86	0.84	0.85	0.88	0.92	0.95	0.92
CP1	0.96	0.92	0.88	0.88	0.86	0.84	0.85	0.88	0.92	0.95	0.92
	3.2	2.2	1.6	1.4	1.1	1.0	0.9	0.9	0.9	1.1	1.1
	4.9	6.6	9.2	6.4	6.9	7.8	6.7	4.1	2.9	1.8	0.5
	0.93	0.86	0.72	0.71	0.79	0.80	0.82	0.88	0.91	0.94	0.92
CP2	0.95	0.90	0.82	0.80	0.82	0.83	0.83	0.88	0.91	0.94	0.92
	8.8	5.7	4.0	3.2	2.8	2.7	2.6	2.6	2.7	2.9	3.1
	21.3	32.2	49.5	41.7	32.3	28.5	23.4	13.5	9.9	5.0	1.5
	0.90	0.81	0.67	0.71	0.76	0.79	0.81	0.86	0.90	0.94	0.90
CP7	0.94	0.87	0.80	0.78	0.77	0.81	0.82	0.87	0.90	0.94	0.91
	17.2	11.1	7.6	6.1	5.4	5.1	5.0	5.2	5.4	5.7	6.0
	57.9	86.1	122.6	94.5	73.5	55.9	41.6	26.8	15.1	6.6	2.6
	0.91	0.82	0.78	0.83	0.85	0.86	0.86	0.91	0.92	0.91	0.80
PP2	0.92	0.84	0.82	0.88	0.90	0.91	0.92	0.94	0.95	0.95	0.87
	8.0	5.4	4.1	4.2	4.4	4.5	4.5	4.7	4.8	4.8	4.1
	38.7	61.1	50.2	24.3	16.7	16.5	13.4	8.9	7.7	4.8	3.4
	0.90	0.81	0.71	0.78	0.81	0.81	0.83	0.87	0.89	0.90	0.80
PP7	0.93	0.86	0.80	0.86	0.89	0.89	0.91	0.93	0.93	0.94	0.89
	17.2	11.3	8.2	7.9	8.2	8.3	8.4	8.6	8.9	9.1	8.3
	70.0	103.4	124.1	65.7	44.0	39.6	29.1	21.7	17.1	12.7	7.4
	0.90	0.80	0.67	0.71	0.75	0.75	0.78	0.79	0.83	0.89	0.82
PP	0.93	0.87	0.80	0.81	0.86	0.84	0.86	0.88	0.90	0.95	0.91
20	47.3	30.4	21.2	18.4	18.7	19.0	19.3	20.0	20.3	20.8	20.2
	186.3	267.2	356.2	232.2	144.2	153.3	116.8	73.5	45.3	23.0	10.7

CP = Constant Poisson PP = Compound Poisson

Appendix K: Results of D033-Implied VMR Test

(H0: Implied VMR is >= Actual VMR)

Item #	# Demands	SCF	Implied VMR	"Actual" VMR	Std Err VMR	Test Stat	Tcrit = -1.310
(Top 20 combinations of AVE_R, DBR & CP-PP for MICS MCC and MDD)							
1.10	63	63	0.35	0.99	0.019	-33.68	Reject
1.20	36.8	36.8	0.20	0.99	0.017	-254.06	Reject
1.30	22.2	22.2	0.12	1.01	0.024	-202.35	Reject
1.40	15.6	15.6	0.09	0.97	0.011	-439.34	Reject
1.80	7.1	7.1	0.04	1.00	0.016	-330.54	Reject
1.11	5.8	5.8	0.03	1.02	0.018	-299.66	Reject
1.16	4.1	4.1	0.02	0.99	0.011	-483.60	Reject
1.32	1.9	1.9	0.01	0.93	0.048	-104.69	Reject
2.20	36.8	110.5	1.84	2.98	0.510	-12.19	Reject
2.40	15.6	46.8	0.78	2.91	0.034	-342.81	Reject
2.11	5.8	17.3	0.29	3.05	0.053	-285.68	Reject
2.16	4.1	12.3	0.21	2.98	0.033	-460.92	Reject
2.32	1.9	5.7	0.10	2.78	0.138	-106.73	Reject
4.30	22.2	57.9	0.84	3.44	0.104	-136.78	Reject
4.50	12.1	31.5	0.46	3.30	0.099	-157.48	Reject
4.70	9.1	23.7	0.34	3.36	0.134	-123.45	Reject
4.11	5.8	14.5	0.20	3.13	0.214	-74.93	Reject
4.32	1.9	4.4	0.06	2.30	0.295	-41.73	Reject
5.20	36.8	216.6	7.08	6.81	0.142	10.56	NR
5.32	1.9	10.3	0.31	5.16	0.496	-53.58	Reject
(Other selected combinations)							
4.10	63.0	164.5	2.39	3.386	0.051	-107.37	Reject
5.30	22.2	130.1	4.24	6.888	0.180	-80.71	Reject
5.32	1.9	10.3	0.31	5.162	0.496	-53.58	Reject
6.10	63.0	1047.2	96.70	17.414	0.329	1320.03	NR
6.20	36.8	611.6	56.47	17.546	0.381	559.56	NR
6.30	22.2	369.7	34.20	17.809	0.490	183.26	NR
6.40	15.6	258.0	23.71	17.031	0.241	151.68	NR
6.50	12.1	200.4	18.44	17.175	0.314	22.05	NR
6.60	10.6	174.0	15.87	17.331	0.385	-20.81	Reject
6.32	1.9	30.2	2.67	15.025	0.935	-72.39	Reject

Appendix L: MIC Simulation Logic Flow Charts

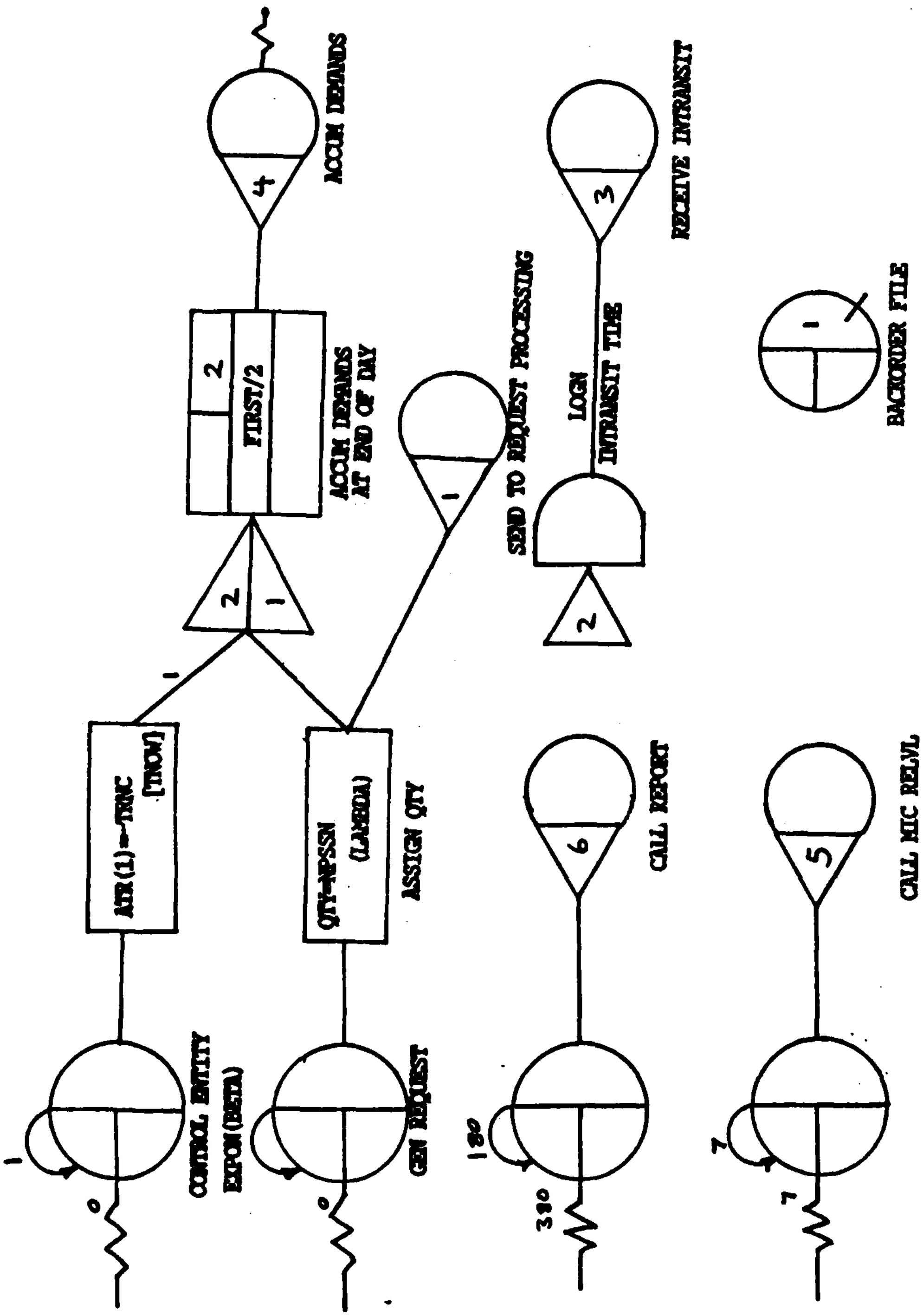

Figure 17. SLAM Model of MIC Logic--1

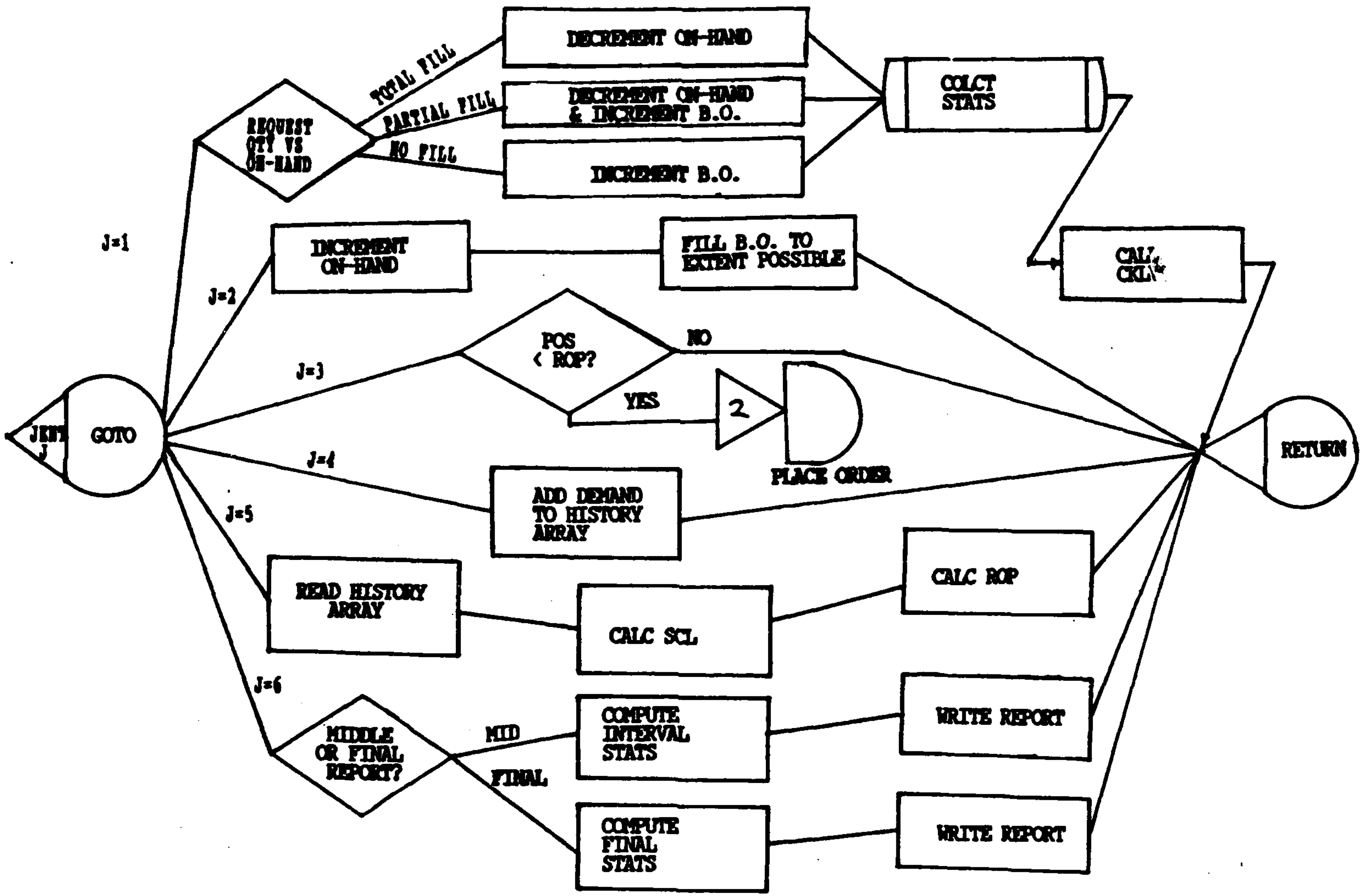

Figure 18. SLAM Model of MIC Logic--2

Appendix M: Demand Data Used in First MIC Simulation
Data Extracted From (5:16)

ITEM #	UNIT COST ($)	ARRIVAL RATE 365/ EARLY CUSTOMERS	# YRLY CUSTOMER	YEARLY UNITS DEMANDED	LOT SIZE (UNITS/ CUSTOMER)
1	4.71	83	4.405	626	7.54
2	2.34	15	24.3	321	21.40
3	0.33	20	18.25	173	8.65
4	42.69	15	24.3	234	15.60
5	3.50	78	4.68	160	2.05
6	0.92	32	11.4	148	4.63
7	0.55	18	20.27	95	5.28
8	1.44	158	2.31	1827	11.56
9	1.15	8	45.63	35	4.38
10	3.38	9	40.55	23	2.56
11	0.20	5	73.00	27	5.40
12	0.67	11	33.18	143	13.00
13	2.20	34	10.73	306	9.00
14	2.25	37	9.86	69	1.86
15	7.60	14	26.07	42	3.00
16	0.35	10	36.50	41	4.10
17	2.85	22	16.59	245	11.14
18	28.10	54	6.76	126	2.33
19	0.73	47	7.77	1853	39.43
20	1.56	159	2.29	1946	12.24

- -

As stated in the AFLMC article (6), was extracted from actual demand data from England AFB. AFLMC "...constructed a sample that

represents typical Air Force consumable items in terms of demand rate and variance of demand" (6:15).

In the above data, the arrival rate is in average days per request received for the item--this will be represented by BETA (average in an exponential distribution) in the SLAM II model.

The average lot size represents (LAMDA) the average quantity of units requested per order. LAMDA is the average in a Poisson distribution. Since SLAM II doesn't have a compound random number generator per se, it is posited that a random exponential interarrival rate (complement to Poisson) combined with a Poisson for the number of units demanded will adequately approximate a compound Poisson. It is further posited that this combined-compound poisson distribution has the same basic ability of characterizing lumpy demands as noted in the literature section of Chapter I, and also parallels the constant-poisson distribution (a type of compound poisson) which an AFLMC study quotes as "...realistically describes demand for items that are ordered in consistent lotsizes and describes demand reasonably well for items where the variance of units ordered is small" (6:17).

Appendix N: SLAM II Source Listing for MIC Simulation

MIC.DAT Network Code

```
GEN,MCBRIDE,MIC,8/6/88,1,N,N,Y/Y,N,N,;
LIMITS,3,6,500;
EQUIVALENCE/XX(15),BETA/
            XX(16),XLAMBDA/
            XX(17),ITEM;
INTLC,BETA=110,XLAMBDA=16.47; BETA= AVE DAYS/RQST, LAMBDA= AVE UNITS/RQST
INTLC,ITEM=6.32;
EQUIVALENCE/XX(1),POS/XX(2),ONHAND/XX(3),SCL/ XX(4),ROP/
            XX(5),TBO/XX(6),OBO/;
EQUIVALENCE/XX(7),O&ST/
            XX(8),QUANT/
            XX(9),YHAT/
            XX(18),XN/XX(19),SUMD/XX(20),SUMD2/
            XX(21),VARD/XX(22),VFLAG/XX(23),VOD/
            XX(24),SIGMA2/
            ATRIB(1),DOR/
            ATRIB(2),RQTY;
; OTHER XX'S USED 10,11,12,13,14 AS COUNTERS ETC
TIMST,XX(1),INV POSITION;
TIMST,XX(2),ON HAND STOCK;
TIMST,XX(3),STOCK CNTRL LVL;
TIMST,XX(4),REORDER POINT;
TIMST,XX(6),OUTSTDNG BO;
;ADDRESS AVG OF XX(6) AS TTAVG(5)
STAT,1,TB BACKORDERS;
STAT,2,SAFETY LEVEL;
STAT,3,CRD DEMAND OBS;
STAT,4,ONE00% FILL OBS;
STAT,5,PARTIAL FILL;
STAT,6,TOTAL UNITS BO;
STAT,7,PARTIAL UNTS BO;
STAT,8,RQTY OBS;
; ** STATS 9 - 14 ARE 30 PERIOD SUMMARY STATS
STAT,9,X BARS OF DEMAND;
STAT,10,VMRS OF DEMAND;
STAT,11,FILL RATE OBS;
STAT,12,AVE ON HAND INV;
STAT,13,AVE BO DAYS UNTS;
STAT,14,NUM OF BO'S  OBS;
STAT,15,LINE ITM FR OBS;
STAT,16,CRD2 DEMAND OBS;
PRIORITY/1,LVF(1);                               BACKORDER FILE
PRIORITY/NCLNR,LVF(1);
; NOTE, TIME UNITS ARE IN DAYS
NETWORK:
      CREATE,,0,,1,1;
      ASSIGN,POS=1,ROP=1,SCL=1,ONHAND=1,TBO=0,OBO=0,II=0,1;
      ASSIGN,XN=0,SUMD=0,SUMD2=0,VFLAG=0;
```

```
      ASSIGN,YHAT=XLAMBDA;
      TERM;
RQST  CREATE,EXPON(BETA,1),1,1,,1;                          CREATE REQUEST
      ASSIGN,DOR=USERF(1);
;CONO  ASSIGN,QUANT=XLAMBDA,1;        USE THIS LINE FOR CONSTANT-POISSON
CONO  ASSIGN,QUANT=NPSSN(XLAMBDA,2),1; USE THIS LINE FOR POISSON-POISSON
      ACT,0,QUANT.GE.1,CON1;
      ACT,0,;
      ASSIGN,QUANT=1.0,1;             GIVEN A RQST OCCURS, QUANT >= 1
CON1  ASSIGN,RQTY=QUANT,1;
      GOON,3;
      ACT,0,,CRD;
      ACT,0,,CON4;                                         REQST TO MIC
      ACT,0,,FRCS;                     ADJUST FORECAST OF EXPECTED RQST
SIZE
CON4  GOON,1;
E1    EVENT,1,1;
T1    TERM;
FRCST EVENT,7,1;
      TERM;
      ENTER,2,1;
CONC  ASSIGN,O&ST=RLOGN(5.466,3.688,3)-0.225,1;       INTRANSIT TIME
      ACT,0,O&ST.GT.0.693.AND.O&ST.LT.10.605,CON2;    KEEP RV O&ST IN
LIMITS
      ACT,0,,CONC;
CON2  GOON,1;
      ACT/2,O&ST;REPLEN;                              GOTO RECEIVE SUBTN
      EVENT,2,1;
      TERM;
CNTRL CREATE,1,1,1;
NEGT  ASSIGN,ATRIB(1)=USERF(2);
CON3  ASSIGN,RQTY=0;
      ACT/8,1;DAILY CYCLE;
CRD   BATCH,2/1,99999,2,FIRST/2,NONE,1;  PUT REQSTS QTY IN DAILY TIME
DOMAIN
      ACT/9;DAILY TOTAL;
ADDIN EVENT,4,1;
      TERM;
; WEEKLY MIC RECOMPUTATION OF SCL AND ROP
      CREATE,7,7;
      EVENT,5;
      TERM;
; OUTPUT SIX MONTH PERFORMANCE MEASURES
      CREATE,180,380;
RPT   EVENT,6;
      TERM;
BO_FL QUEUE(1);
      TERM;
      END;
INIT,0,5600.1;
;MONTR,TRACE(RQST,CNTRL,NEGT,CON3,CRD,ADDIN,RPT),560,570.99,1,2;
;MONTR,TRACE,0,2.0,1,2;
;MONTR,SUMRY,3620;
```

```
MONTR,CLEAR,200;
MONTR,CLEAR,380.001;
MONTR,CLEAR,560.001;
MONTR,CLEAR,740.001;
MONTR,CLEAR,920.010;
MONTR,CLEAR,1100.001;
MONTR,CLEAR,1280.001;
MONTR,CLEAR,1460.001;
MONTR,CLEAR,1640.001;
MONTR,CLEAR,1820.001;
MONTR,CLEAR,2000.001;
MONTR,CLEAR,2180.001;
MONTR,CLEAR,2360.001;
MONTR,CLEAR,2540.001;
MONTR,CLEAR,2720.001;
MONTR,CLEAR,2900.001;
MONTR,CLEAR,3080.001;
MONTR,CLEAR,3260.001;
MONTR,CLEAR,3440.001;
MONTR,CLEAR,3620.001;
MONTR,CLEAR,3800.001;
MONTR,CLEAR,3980.001;
MONTR,CLEAR,4160.001;
MONTR,CLEAR,4340.001;
MONTR,CLEAR,4520.001;
MONTR,CLEAR,4700.001;
MONTR,CLEAR,4880.001;
MONTR,CLEAR,5060.001;
MONTR,CLEAR,5240.001;
MONTR,CLEAR,5420.001;
FIN;
```

MAIN.FOR FORTRAN SUBROUTINES

```
      PROGRAM MAIN
      DIMENSION NSET(10000)
      INCLUDE 'PARAM.INC'
      COMMON/SCOM1/ATRIB(MATRB), DD(MEQT), DDL(MEQT), DTNOW, II, MFA,
     1MSTOP,NCLNR, NCRDR, NPRNT, NNRUN, NNSET, NTAPE, SS(MEQT),
     2SSL(MEQT),TNEXT, TNOW, XX(MMXXV)
      COMMON QSET(10000)
      EQUIVALENCE (NSET(1),QSET(1))
      NNSET=10000
      NCRDR=5
      NPRNT=6
      NTAPE=7
      CALL SLAM
      STOP
      END
C
      SUBROUTINE EVENT(I)
      INCLUDE 'PARAM.INC'
```

```
      COMMON/SCOM1/ATRIB(MATRB), DD(MEQT), DDL(MEQT), DTNOW, II, MFA,
     1MSTOP,NCLNR, NCRDR, NPRNT, NNRUN, NNSET, NTAPE, SS(MEQT),
     2SSL(MEQT),TNEXT, TNOW, XX(MMXXV)
      GO TO (1,2,3,4,5,6,7),I
    1 CALL REQST
      RETURN
    2 CALL RECEV
      RETURN
    3 CALL CKLVL
      RETURN
    4 CALL CRD
      RETURN
    5 CALL RELVL
      RETURN
    6 CALL OTPUT
      RETURN
    7 CALL FRCST
      RETURN
      END
C
      SUBROUTINE FRCST
      INCLUDE 'PARAM.INC'
      COMMON/SCOM1/ATRIB(MATRB), DD(MEQT), DDL(MEQT), DTNOW, II, MFA,
     1MSTOP,NCLNR, NCRDR, NPRNT, NNRUN, NNSET, NTAPE, SS(MEQT),
     2SSL(MEQT),TNEXT, TNOW, XX(MMXXV)
      EQUIVALENCE (YHAT,XX(9))
      EQUIVALENCE (XN,XX(18))
      EQUIVALENCE (SUMD,XX(19))
      EQUIVALENCE (SUMD2,XX(20))
      EQUIVALENCE (VARD,XX(21))
      EQUIVALENCE (RQTY,ATRIB(2))
C *** ESTIMATE EXPECTED REQUEST SIZE USING EXPONENTIAL SMOOTHING
      A=0.03
      YHAT=A*RQTY+(1.0-A)*YHAT
C *** COMPUTE VARIANCE OF DEMAND
      SUMD2=SUMD2+RQTY**2.0
      SUMD=SUMD+RQTY
      XN=XN+1.0
      VARD=(SUMD2-(SUMD**2.0)/XN)/XN
      IF(VARD.LT.0.001) VARD=0.002
      RETURN
      END
C
      SUBROUTINE REQST
      INCLUDE 'PARAM.INC'
      COMMON/SCOM1/ATRIB(MATRB), DD(MEQT), DDL(MEQT), DTNOW, II, MFA,
     1MSTOP,NCLNR, NCRDR, NPRNT, NNRUN, NNSET, NTAPE, SS(MEQT),
     2SSL(MEQT),TNEXT, TNOW, XX(MMXXV)
      EQUIVALENCE (POS,XX(1))
      EQUIVALENCE (ONHAND,XX(2))
      EQUIVALENCE (SCL,XX(3))
      EQUIVALENCE (ROP,XX(4))
      EQUIVALENCE (TBO,XX(5))
```

```
      EQUIVALENCE (RQTY,ATRIB(2))
      EQUIVALENCE (OBO,XX(6))
      CALL COLCT(RQTY,8)
C *** FILL REQUEST AS MUCH AS POSSIBLE
      IF(ONHAND.GE.RQTY) GOTO 20
      IF(ONHAND.LE.0.) GOTO 10
C *** PARTIAL FILL, PARTIAL BACKORDER
      POS=POS-RQTY
      ATRIB(2)=RQTY-ONHAND
      CALL FILEM(1,ATRIB)
      OBO=OBO+ATRIB(2)
      CALL COLCT(ONHAND,5)
      CALL COLCT(ATRIB(2),7)
      ONHAND=0.
      TBB=TNOW-TBO
      CALL COLCT(TBB,1)
      TBO=TNOW
      CALL CKLVL
      RETURN
C *** 0% FILL, BACKORDER ENTIRE REQUEST
10    POS=POS-RQTY
      ATRIB(2)=RQTY
      CALL FILEM(1,ATRIB)
      OBO=OBO+ATRIB(2)
      CALL COLCT(ATRIB(2),6)
      TBB=TNOW-TBO
      CALL COLCT(TBB,1)
      TBO=TNOW
      CALL CKLVL
      RETURN
C *** FILL REQUEST, 100%
20    POS=POS-RQTY
      ONHAND=ONHAND-RQTY
      CALL COLCT(RQTY,4)
      CALL CKLVL
      RETURN
      END
C
      SUBROUTINE RECEV
      INCLUDE 'PARAM.INC'
      COMMON/SCOM1/ATRIB(MATRB), DD(MEQT), DDL(MEQT), DTNOW, II, MFA,
     1MSTOP,NCLNR, NCRDR, NPRNT, NNRUN, NNSET, NTAPE, SS(MEQT),
     2SSL(MEQT),TNEXT, TNOW, XX(MMXXV)
      EQUIVALENCE (POS,XX(1))
      EQUIVALENCE (ONHAND,XX(2))
      EQUIVALENCE (SCL,XX(3))
      EQUIVALENCE (ROP,XX(4))
      EQUIVALENCE (OBO,XX(6))
      CALL COLCT(ONHAND,2)
      ONHAND=ONHAND+ATRIB(2)
C *** POSSIBILY 100% FILL BACKORDERS
5     IF(NNQ(1)) 30,30,10
10    CALL COPY(1,1,ATRIB)
```

```
      IF(ONHAND.LT.ATRIB(2)) GOTO 20
      CALL RMOVE(1,1,ATRIB)
      OBO=OBO-ATRIB(2)
      ONHAND=ONHAND-ATRIB(2)
      IF(ONHAND) 30,30,5
20    CALL RMOVE(1,1,ATRIB)
      ATRIB(2)=ATRIB(2)-ONHAND
      OBO=OBO-ONHAND
      ONHAND=0
      CALL FILEM(1,ATRIB)
30    RETURN
      END
C
      SUBROUTINE CKLVL
      INCLUDE 'PARAM.INC'
      COMMON/SCOM1/ATRIB(MATRB), DD(MEQT), DDL(MEQT), DTNOW, II, MFA,
     1MSTOP,NCLNR, NCRDR, NPRNT, NNRUN, NNSET, NTAPE, SS(MEQT),
     2SSL(MEQT),TNEXT, TNOW, XX(MMXXV)
      EQUIVALENCE (POS,XX(1))
      EQUIVALENCE (ONHAND,XX(2))
      EQUIVALENCE (SCL,XX(3))
      EQUIVALENCE (ROP,XX(4))
C *** CHECK LEVEL TO DETERMINE IF MIC REPLEN IS NEEDED
      IF(POS.GT.(ROP+0.1)) RETURN
      IF(POS.EQ.SCL) RETURN
C *** PLACE REPLEN TO D033 TO GET POS TO SCL
      ATRIB(2)=AINT(SCL-POS+0.1)
      POS=SCL
      CALL ENTER(2,ATRIB)
      RETURN
      END
C
      SUBROUTINE CRD
      INCLUDE 'PARAM.INC'
      COMMON/SCOM1/ATRIB(MATRB), DD(MEQT), DDL(MEQT), DTNOW, II, MFA,
     1MSTOP,NCLNR, NCRDR, NPRNT, NNRUN, NNSET, NTAPE, SS(MEQT),
     2SSL(MEQT),TNEXT, TNOW, XX(MMXXV)
      EQUIVALENCE (RQTY,ATRIB(2))
      CALL COLCT(RQTY,3)
      IF(ABS(ATRIB(1)).LE.1) II=0
C *** ACCUMULATE DEMANDS IN XX(51-230)
      IF(II.GT.180) II=II-180
      XX(50+II)=RQTY
      II=II+1
      RETURN
      END
C
      SUBROUTINE RELVL
      INCLUDE 'PARAM.INC'
      COMMON/SCOM1/ATRIB(MATRB), DD(MEQT), DDL(MEQT), DTNOW, II, MFA,
     1MSTOP,NCLNR, NCRDR, NPRNT, NNRUN, NNSET, NTAPE, SS(MEQT),
     2SSL(MEQT),TNEXT, TNOW, XX(MMXXV)
      EQUIVALENCE (SCL,XX(3))
```

```
      EQUIVALENCE (ROP,XX(4))
      EQUIVALENCE (XLAMDA,XX(16))
      EQUIVALENCE (YHAT,XX(9))
      EQUIVALENCE (XN,XX(18))
      EQUIVALENCE (VARD,XX(21))
      EQUIVALENCE (VFLAG,XX(22))
      EQUIVALENCE (VOD,XX(23))
      EQUIVALENCE (SIGMA2,XX(24))
      DOUBLE PRECISION DDR
      SIGMA=0.
C *** XX(51 - 230) IS THE ARRAY HOLDING MOVING SIX MOS REQUEST HISTORY
      DO 10 I=1,180
      CALL COLCT(XX(50+I),16)
10    SIGMA=SIGMA+XX(50+I)
      DDR=SIGMA/180.
      IF(TNOW.LT.183) SIGMA2=SIGMA
C *** USE EXPONENTIAL SMOOTHING W/ SIGMA2 FOR USE IN STK CNTRL LVL LIMIT

      SIGMA2=0.05*SIGMA+0.95*SIGMA2
C *** COMPUTE VARIANCE OF DEMAND
      VOD=CCSTD(16)**2.0
C *** TAKE VOO AS GIVEN (S^2) IN SLAM NETWORK
      VOO=13.6
C
C *** THE FOLLOWING TWO LINES ARE FOR '(30/15)DAY' STOCKAGE POLICY
C      SCL=AMAX1(AINT((SIGMA/6.0)+0.99),1.0)
C      ROP=AMAX1(AINT((SIGMA/12.0)+0.99),1.)
C
C *** THE FOLLOWING TWO LINES ARE FOR '(7/3.5)DAY' STOCKAGE POLICY
C      SCL=AMAX1(AINT(SIGMA/25.71+.99),1.)
C      ROP=AMAX1(AINT(SIGMA/51.43+.99),1.)
C
C *** THE FOLLOWING 22 LINES ARE FOR A MODIFIED "LOT FOR LOT" W/SL POLICY

      VFLAG=0.0
      SCL1A=AINT(YHAT+(1.65*SQRT(YHAT))+0.5)
      SCL1B=AINT(YHAT+(1.65*SQRT(VARD))+0.5)
      IF((XN.GT.10.0).AND.(SCL1B.GT.(3.0*YHAT))) VFLAG=3.0
C *** MAX, LIMIT SCL1B TO 3*AVE LOT SIZE (MIN = AINT(YHAT+.5))
      SCL1B=AMIN1(SCL1B,AINT(YHAT*3.0+.99))
      SCL1=AMIN1(SCL1A,SCL1B)
C *** ONLY USE SCL1B IF >= 10 REQUESTS OBSERVED
      IF(XN.LT.10.0) SCL1=SCL1A
C *** SET VAR FLAG FOR OUTPUT IF SCL1 > 180 DAYS "WORTH" OF STOCK
      IF(SCL1.GT.(AINT(SIGMA2+0.99)).AND.TNOW.GT.220.) VFLAG=1.0
C *** MIN "1.5 DAY" + SAFETY LEVEL FOR O&ST & DDR VARIANCE
      SCL2=AINT(5.241*DDR+1.65*SQRT(1.5*VOD+(DDR**2.0)*VOO)+0.9)
      IF(SCL2.GT.(AINT(SIGMA2+0.99)).AND.TNOW.GT.220.) VFLAG=2.0
C *** USE LARGER OF SCL1 OR SCL2 AS INTERMEDIATE COMP
      SCL3=AMAX1(SCL1,SCL2,1.0)
C *** CREATE UPPER LIMIT ON STOCK LEVEL
      SCL=AMIN1(SCL3,AINT(SIGMA2+0.99))
      IF(TNOW.LT.220.0) SCL=SCL3
```

```
      ROP=AMAX1((AINT(SCL-0.9)),1.0)
C *** INTERMEDIATE OPTIONAL TRACE TO TEST MODEL3 RESPONSE AND
CALCULATIONS
C       WRITE(NPRNT,30) YHAT,SCL1A,SCL1B,IFIX(XN),SCL1,SCL2,SCL3,
C      1SCL,ROP,IFIX(VFLAG),SIGMA2,TNOW
C30     FORMAT(' L30 ',F4.1,F5.0,F5.0,I5,F5.1,F5.1,F5.1,
C      1F5.1,F5.1,2X,I1,F5.0,F8.2)
C
40    CALL CKLVL
      RETURN
      END
C
      FUNCTION USERF(I)
      INCLUDE 'PARAM.INC'
      COMMON/SCOM1/ATRIB(MATRB), DD(MEQT), DDL(MEQT), DTNOW, II, MFA,
     1MSTOP,NCLNR, NCRDR, NPRNT, NNRUN, NNSET, NTAPE, SS(MEQT),
     2SSL(MEQT),TNEXT, TNOW, XX(MMXXV)
      GOTO (1,2),I
1     USERF=AINT(ATRIB(1))
      RETURN
2     USERF=(-1*AINT(ATRIB(1)))
      RETURN
      END
C
      SUBROUTINE OTPUT
      INCLUDE 'PARAM.INC'
      COMMON/SCOM1/ATRIB(MATRB), DD(MEQT), DDL(MEQT), DTNOW, II, MFA,
     1MSTOP,NCLNR, NCRDR, NPRNT, NNRUN, NNSET, NTAPE, SS(MEQT),
     2SSL(MEQT),TNEXT, TNOW, XX(MMXXV)
      EQUIVALENCE (J,XX(10))
      EQUIVALENCE (XD,XX(11))
      EQUIVALENCE (XR,XX(12))
      EQUIVALENCE (XITEM,XX(17))
      EQUIVALENCE (VFLAG,XX(22))
      CHARACTER*4 FLAG/'    '/
      IF(TNOW.GT.400) GOTO 5
      J=1
      XAVE=0.
      XVMR=0.
      XFILL=0.
      XD=0.
      XR=0.
C *** XX(241 - 270) HOLD THE X BAR'S OBS
C *** XX(271 - 300) HOLD THE VMR'S OBS
C *** XX(301 - 330) HOLD FILLRATE OBSERVATIONS
C *** XX(331 - 360) HOLD AVE ON HAND STOCK LEVELS FOR PERIODS
C *** XX(361 - 390) HOLD AVE OBO-DAYS (IN UNITS) OBSERVATIONS
C *** XX(391 - 420) HOLD # OF BACKORDERS PLACED IN PERIODS (NOT UNITS)
C *** XX(421 - 450) HOLD LINE ITEM FILL RATE OBSERVATIONS
C *** OPTIONAL 180 INTERVAL OUTPUT
C *** PRINT HEADER *************
C       WRITE(NPRNT,1)
C1      FORMAT('             ')
```

```
C      WRITE(NPRNT,2) XX(15),XX(16)
C2     FORMAT('  ************ FOR BETA = ',F8.3,'  AND LAMDA =',F8.3,
C     1' ************')
C      WRITE(NPRNT,3)
C3     FORMAT(' TNOW    DDR MEAN   DMD VAR     VMR
C     1  U FILLRT  # RQSTS  TOT U RQSTD  J')
C
C *** CALCULATE THE AVE (DDR), VAR AND VAR TO MEAN RATIO (VMR)
5     CONTINUE
C ***   CHANGE THE 5600... IF CHANGING LENTH OF SIMULATON,ETC
      IF(TNOW.GE.5600.01) GOTO 30
C *** AVE IS THE DAILY DEMAND RATE (DDR)
      AVE=CCAVG(3)
      XX(240+J)=AVE
      XAVE=XAVE+AVE
      STD=CCSTD(3)
      TOT=AVE*CCNUM(3)
      VAR=STD*STD
      XVAR=XVAR+VAR
      VMR=0.0
      IF(AVE.GT.0.004) VMR=VAR/AVE
      XX(270+J)=VMR
      XVMR=XVMR+VMR
C *** CALCULATE THE FILL RATE
C *** AVE2 IS AVE OF QUANTITIES REQUESTED
      AVE2=CCAVG(8)
      TOT2=AVE2*CCNUM(8)
      TFILL=CCAVG(4)*CCNUM(4)
      PFILL=CCAVG(5)*CCNUM(5)
      TNFIL=TFILL+PFILL
      FILRT=0.0
      IF(TOT2.GT.0.05) FILRT=TNFIL/TOT2
      XX(300+J)=FILRT
      XFILL=XFILL+FILRT
C
C *** STORE OBS FOR FR, ON-HAND LEVEL, AVE-OBO AND # BO'S FOR LATER
SUMMARY
      XX(330+J)=TTAVG(2)
      XX(360+J)=TTAVG(5)
      XX(390+J)=CCNUM(6)+CCNUM(7)
      XX(420+J)=0.0
      IF(CCNUM(8).GT.0.5) XX(420+J)=CCNUM(4)/CCNUM(8)
      XD=XD+TOT2
      XR=XR+CCNUM(8)
C *** OPTIONAL 180 DAY INTERVAL STATS
C      IF(TNOW.GT.700.0) GOTO 11
C *** PRINT OUT SIX MONTH STATS ****
C      WRITE(NPRNT,10) IFIX(TNOW),AVE,VAR,VMR,FILRT,CCNUM(8),TOT2,J
C10    FORMAT(I6,F10.3,F10.3,F10.3,F10.3,F10.0,F10.0,3X,I2)
C11    CONTINUE
      IF(TNOW.LT.5500) GOTO 30
C *** PRINT OUT SUMMARY STATS FOR 30 6 MOS CYCLES ********
C *** READ XBAR, VMR, FR, OH, OBO, BO OBS INTO STAT FILES 9 - 14
```

```
      DO 12 K=1,30
      CALL COLCT(XX(240+K),9)
      CALL COLCT(XX(270+K),10)
      CALL COLCT(XX(300+K),11)
      CALL COLCT(XX(330+K),12)
      CALL COLCT(XX(360+K),13)
      CALL COLCT(XX(390+K),14)
12    CALL COLCT(XX(420+K),15)
C
      IF(VFLAG.GT.0.5.AND.VFLAG.LT.1.5) FLAG='LIM1'
      IF(VFLAG.GT.1.5.AND.VFLAG.LT.2.5) FLAG='LIM2'
      IF(VFLAG.GT.2.5.AND.VFLAG.LT.3.5) FLAG='LIM3'
      IF(VFLAG.LT.0.5.OR.VFLAG.GT.3.5) FLAG='    '
      WRITE(NPRNT,13) XITEM
13    FORMAT(' + - ITEM ',F4.2,' - - 30-6 MONTH SUMMARY STATS - -
     1LOT 4 LOT W/SF POLICY - +')
      WRITE(NPRNT,15) FLAG
15    FORMAT(' X__DDR   STD XBAR   X_VMR
     1   X_FILLR  X_RQSTS  X_URQSTD    BETA  ',A4)
      WRITE(NPRNT,20) (XAVE/J),CCSTD(9),XVMR/J,XFILL/J,
     1(XR/J),(XD/J),XX(15)
20    FORMAT(' ',F6.3,F9.3,F10.3,F10.4,F8.1,F10.1,F10.2)
      WRITE(NPRNT,25) (CCSTD(10)/SQRT(FLOAT(J))),
     1(CCSTD(11)/SQRT(FLOAT(J))),XX(16)
25    FORMAT(' STD ERR OF X_VMR=',F6.3,'   STD ERR OF X_FILLR=',
     1F6.3,'   LAMBDA= ',F6.3,' UPR')
      WRITE(NPRNT,26) CCAVG(12),(CCSTD(12)/SQRT(30.0)),
     1((CCAVG(14)*2.0)+0.9)
26    FORMAT(' AVE ON-HAND= ',F7.3,'  STD ERR OF ON-HAND= ',F5.3,
     1'  AVE # BO RQSTS/YR=',F5.1)
      WRITE(NPRNT,27) (CCAVG(13)*TTPRD(5)*2.0),
     1(CCSTD(13)/SQRT(30.0),CCAVG(15),(CCSTD(15)/SQRT(30.0)))
27    FORMAT(' AVE BO-DAYS(U)/YR=',F7.2,'  SE AVE OBO(U)=',
     1F6.4,'  X__LI_FR=',F5.3,' SE'F4.3,' +')
C ****** END OF THIS CYCLE (OR SUMMARY IF TNOW > 5600) *******
30    CONTINUE
      J=J+1
      RETURN
      END

C  PARAM.INC from ad$sw:[slam]
C  MATERIAL HANDLING EXTENSION VERSION 2.1 PARAMETERS
      PARAMETER (MXCRN=20,  MXSPA=75,  MXPIL=200, MXTRK=10,
     1           MXCPR=10,  MXYLOC=21000, MXVCPO=160,
     2           MXVSEG=200,MXVSET=10,MXVUNI=50)
C
C  SLAM II REGULAR VERSION PARAMETERS  (with modificatons for MIC.DAT)
      PARAMETER (MEQT=100,  MSCND=25, MENTR=50,  MRSC=75, MARR=50,
     1  MGAT=25, MHIST=50, MCELS=500, MCLCT=50, MSTAT=50,MEQV=100,
     2  MATRB=100, MFILS=100, MPLOT=10,  MVARP=10,  MSTRM=10,
     3  MACT=100, MNODE=500, MITYP=50, MMXXV=450, MMXFLD=50)
      PARAMETER ( MAXLVL=50,MXMACS=20,MXBRKS=10)
      PARAMETER (MVARP1=MVARP+1)
```

Appendix O: Definitions Relating to Depot Maintenance and Depot Supply

Terms Explained. It must be recognized that the same terms may have different meanings in other areas of Air Force activity. The following terms are direct in whole or abbreviations from AFLCR 66-53, AFM 67-1, and the D033 Technical Support Manual (3:9-36;9;1).

ACTION/SUFFIX CODE - A two position alpha code either manually assigned or machine generated to a request for the purpose of identifying the action to be taken by the computer.

ADVICE CODE - A code used by the requestor instructing the source of supply how to fill the requisition.

AIR LOGISTICS CENTER (ALC) - An AFLC operational activity charged with world wide responsibility for receiving, storing and shipping material, organically accomplishing repair and modification tasks, contracting with industry for manufacture or repair as directed by Materiel Management (MM) for assigned weapon systems, equipment or items of supply, and providing technical and logistics support for AF operational units, other service agencies and foreign military customers.

BACKORDER (BO/DO/BB) - Material that is not available for issue from DS. This is the same as a due-out. It is a computer recorded obligation by DS to issue material at a subsequent date.

BASE DELIVERY PRIORITY CODE - A numeric code which indicates the maximum time which DS has to deliver the material to the requester or action has been completed to forward the requirement to the next higher level of supply.

BENCH STOCK ITEMS - A 30-day stock of "N" ERRC coded indirect consumption material items authorized for free access in a production shop area to ensure an uninterrupted work flow.

BILL OF MATERIAL (BOM) - A descriptive and quantitative listing of material, supplies, parts, and components required to produce a designated complete end-item, assembly, or subassembly, to overhaul or repair such an item, or to construct or repair a structure or facility item. Listing may also show estimated costs.

CANNIBALIZATION/ROBBACK - The authorized removal of specific components from one end item to meet priority requirements on another end item. There is an obligation to replace the removed components when material is made available. Cannibalizations are authorized by the Item Manager (IM). Robbacks are authorized by the scheduler.

CENTRALLY PROCURED (CP) - Stocklisted items supplied through one central agency, the System Support Division, Air Force Stock Fund (fund code "6H", budget code "1") with a "CP" procurement code.

COMMON ITEM - An item of supply having application to two or more systems or subsystems, including components and spares.

COMPONENT ITEM - Material, usually stock numbered, which is an identifiable entity contained in a next higher assembly. A component item may, in itself, be an end item when handled as such in the workload.

CRITICAL ITEM - Item Managers label some exchangeable items as "critical" so they will receive high priority handling throughout the repair cycle.

DAILY DEMAND RATE (DDR) - The DDR is computed by dividing the stock level factor by the day's experience.

DAYS EXPERIENCE - The days of experience on an item is computed by subtracting the current date from the stock level begin date.

DEFENSE LOGISTICS AGENCY (DLA) - A central procurement agency of supply for material such as nuts, bolts, screws, electronic parts, etc., for all DOD agencies. Material may be stocked at various centers within the DLA complex.

DEMAND LEVEL - A term used to identify the DS stockage objective based upon demand history.

DEPOT LEVEL MAINTENANCE(DLM) - The maintenance, repair or modification of an end item or equipment requiring major overhaul or complete rebuilding of certain parts and usually provided for only at an AF Depot or contractor overhaul facility.

DIRECT MATERIAL - That material required by and identifiable to an MA job order/end item. Direct material will become a part of the end item or other item which is undergoing maintenance or it may be consumed in the maintenance production process, e.g., heat treating, plating, or painting, when the consumed material is peculiar to the item produced. Items that must be classified as direct material include: serial number controlled, exchange, T.O. kit, organically manufactured items, components for organic manufacture, items classified as direct material in the same cost center, and those items considered peculiar, critical or increased control is required.

D002A - USAF Standard Base Supply System (SBSS)-The data system used at base level for equipment/supplies and base aviation fuels accounts throughout the Air Force. It is used at depot level for tools, fuels, lumber, country store items, etc.

D033 - AFLC Retail *Stock Control* and Distribution - Central Material Locator System. The data system used to provide supply support to Depot Maintenance. The D033 system is the primary supply support system for Depot Maintenance. Management of material through the D033 rather than the D002A system should be maximized.

DOCUMENT IDENTIFIER - A code used to identify the type of action to be accomplished by a particular transaction.

DOCUMENT NUMBER - A unique number assigned to a transaction to maintain control and accountability of the material transactions.

DUE-IN - DS term for the material they have on backorder. The quantity of items on order with a source of supply but not yet delivered.

DUE-OUT - DS term for an MA backorder.

EOQ - Economic order quantity.

END ITEM. Equipment or material of distinct identity, handled as an identifiable workload and assigned a control number.

ESTIMATED DELIVERY DATE (EDD) - The date the material is expected to be delivered to the base for issue to local customers.

EXCHANGE ITEM - A reparable item which is turned in or repaired and a serviceable replacement is issued. (See Investment material).

EXPENDABILITY-RECOVERABILITY REPARABILITY-CATEGORY (ERRC) CODE - A single or three digit code used to classify level of repair of Air Force items.

EXPENSE MATERIAL - Material financed and managed under the Air Force Stock Fund which is recorded as an expense to the Depot Maintenance Industrial Fund upon issue from DS.

FORCE/ACTIVITY DESIGNATOR (FAD) - This is a part of the priority established for requesting material. The FAD is determined based on the relative importance of the work done by a particular activity. The FAD is a single digit numeric and is used in conjunction with the urgency of need designator (UND). The FAD is assigned by the Joint Chiefs of Staff.

FUNDS CODE - A code designating financial management responsibilities:

"6C" - General Support Division (Managed by DS). Items that cannot be directly tied to an Air Force managed system.

"6H" - System Support Division (Managed by Prime). Items that are tied directly to an Air Force managed system.

G004H - Maintenance Actual Material Cost System (MAMCS). Reports cost of actual material consumed by Depot Maintenance in the repair process.

G005M - Depot Maintenance Material Support System. This system is used to maintain material standards data and then forecast the future material required by Depot Maintenance through established bills of material (BOM).

G019C - MISTR Requirements Scheduling and Analysis System. This system produces the MISTR consolidated schedule and is used to identify end item quantities for the quarterly MISTR drive. AFLCM 65-296, Management of Items Subject to Repair (MISTR) will replace AFLCR 65-12, MISTR.

INDIRECT MATERIAL - Material that is costed to an overhead control number (UXXXX) because it cannot be easily identified to a particular end item or system.

INTERROGATION. The process for obtaining specific information contained within a computer system.

INVENTORY - Material stored in an assigned location. The term "inventory" is also used as a physical count of material to compare the amount stored in the assigned location with the amount shown on the system accountable records.

INVESTMENT MATERIAL - Recoverable assemblies, modification kits and other materials procured with investment (Central Procurement) appropriations, ERRC codes C and T.

ISSUE - A transfer of accountability and movement of material to a requesting organization.

ISSUE DOCUMENT - A form that is generated as a result of an issue of material from DS or a Maintenance Inventory Center (MIC).

ITEM MANAGER (IM) - The prime item manager has worldwide control over procurement and distribution of a certain designated group of NSNs. The DS item manager has local control over procurement and distribution of a designated group of NSNs.

JOB DESIGNATOR (JD) - The sixth position alpha code assigned to a JON to signify the type and extent of depot maintenance authorized. (See AFLCR 66-60 for definition of job designators.)

JOB ORDER NUMBER (JON) - A nine position number used to control workload for the project order period on which funding is provided. The number consists of a five position control number, a one position job designator and a three position JON suffix.

JON SUFFIX - A three position alpha-numeric suffix which is added to the six position production number to form the job order number. The first position denotes the fiscal year or the first character of the weapon system I.D., if serialized. The second position denotes the fiscal quarter (numeric) or month (alpha), or second position of the weapon system I.D. The third position denotes the ownership purpose code or the last position of the weapon system.

LINE ISSUE - Movement of material from a MIC or DS to the production shops.

LOCAL PURCHASE (LP) - A source of supply whereby material is procured through a local procurement agency. Although sources may be far away, local procurement is used because DOD has determined it to be more economical to purchase some item on an "as needed" basis rather than to keep it stocked at DOD agencies worldwide.

MAINTENANCE INVENTORY CENTER (MIC) - A stock point owned and operated by MA. MIC's provide interim storage of direct and indirect material for issue to RCC's to support the production effort. The number and location of MICs depend on local MA needs (3:42).

MAINTENANCE INVENTORY CENTER (MIC) REPLENISHMENT - The process of replenishing MIC stockage for subsequent line issue.

MAJOR ASSEMBLY - An item made up of component items, some of which may themselves be end items.

MANAGEMENT OF ITEMS SUBJECT TO REPAIR (MISTR) - A system developed to control and schedule the repair of investment items on a recurring basis. See G019C.

MATERIAL REQUIREMENTS PLANNING (MRP) - The basic principle that identifies stock requirements for a future timeframe. It may be determined by calculating gross requirements as equal to parts requirements per end items, as indicated by the material standard items, multiplied by the expected workload. The net parts requirements equals the gross requirements minus expected on-hand balance.

MATERIAL STANDARD (BILL OF MATERIAL) - A G005M product developed by MA_E personnel, of standard material requirements which when combined with other management system data enables development of standard costs, material requirements planning (projections) and supportability determination.

MISSION CAPABILITY (MICAP) - A code used to identify those components which are causing weapon systems not to be capable of performing the mission for which they were designed.

NONRECURRING DEMAND - A request for issue made by an authorized customer on a one-time basis, or a request for modification of equipment, special planned programs, or one-time repair or rebuild requirements.

NONSTOCKLISTED (NSL) - An item that does not have an NSN assigned. The items that would fall into this category would include items identified under one of the AF control numbers.

NOT MISSION CAPABLE SUPPLY (NMCS) - A condition status of a weapon system or selected item of equipment that is not capable of performing all of its assigned missions due to lack of parts.

ON WORK ORDER (OWO) - Items in the repair cycle in Maintenance that have direct relationship to the DIOH.

OSTQ - Order and ship time quantity.

ORGANIC DEPOT MANUFACTURING - When the MA facilities become the source of supply and manufacture is accomplished in the depot shop. Previously known as local manufacture.

PART NUMBER (P/N) - A number assigned by the manufacturer of an item. This is converted by the Air Force to a stock number (either NSN, "P", or "L" stock number). A "P" number is a temporary number assigned by DS while waiting for a permanently assigned NSN.

PLANNED MATERIAL - Indicates that material is planned by NSN, Unit per Assembly(UPA) and replacement percent on an MA BOM.

PLT - Pipeline time.

PRIORITY DESIGNATOR - A two digit numeric code from 01 to 13 which results from the combination of an assigned Force Activity Designator (FAD) and a locally determined Urgency of Need designator (UND).

PRODUCTION ITEM - An item processed through a repair facility for repair, modification, manufacture, etc.

RECURRING DEMAND - A request made periodically or anticipated to be repetitive by an authorized requisitioner for material for consumption or for stock replenishment.

REORDER LEVEL (ROL) - The stock position when replenishment is required.

REPAIR - The restoration or replacement of parts or components of material as necessitated by wear and tear, damage, or failure of parts in order to return an item to serviceable condition. Items which can be repaired for reuse when they become unserviceable are referred to as reparables.

REQUEST FOR ISSUE - A transaction initiated by a customer to obtain material from a source of supply.

REQUISITION - A transaction initiated by DS to obtain material from a wholesale level supply source.

REQUISITIONING OBJECTIVE - The sum of the reorder point, special levels, safety level and any DMSK additive level. Also known as stockage objective.

ROBBACK - MA authorized removal of an assembly, subassembly, or component part from an aircraft or end item within the maintenance repair process to repair a like aircraft or end item for the purpose of meeting specific schedules. Robbacks will only be accomplished after all other sources of supply have been exhausted.

SAFETY LEVEL - That quantity of an item needed to permit continuous operation during stock replenishment cycle with a specified level of confidence, providing normal resupply lead time is uninterrupted and or demand remains fairly constant.

SLQ - Safety level quantity. Used in D033 calculations.

SOURCE OF SUPPLY (SOS) - The agency to which requisitions are sent for resupply action.

SLQ - Safety level quantity. Used in D033 Calculations.

SPECIAL LEVEL - A manually assigned stock level. The minimum or maximum quantity required to be on-hand or on-order for specific purposes.

SCF - Stock control factor. Used in D033 calculations.

STOCK FUND - A stock fund is a revolving fund established to finance inventories of supplies and other stores. It is authorized by specific provision of law to finance a continuing cycle of operations. Receipts derived from Maintenance operation are then available for further use.

STOCK LEVEL (SL) - A system computed requirement for stockage.

SLBD - Stock level begin date. Date used in D033 calculations.

TECHNICAL ORDER COMPLIANCE (TOC) - Periodic inspection, test, calibration, modification, change or alteration of an item by a Maintenance function before shipment, issue or storage can be accomplished.

TIME COMPLIANCE TECHNICAL ORDER (TCTO) - An authorized directive issued to provide instructions to Air Force activities for accomplishing one-time changes, modifications, inspection of equipment, or installation of new equipment within a given time frame.

TRANSACTION - The movement of data between two records in a computer system.

TURN-IN - A transaction whereby property is moved from the MA production line to Supply, MIC, or from MIC to Supply.

UNIT OF ISSUE - Denotes the physical measurement, count, or when neither is applicable, the container or shape of an item for issue to the end user. It is that element of management data to which the unit price is ascribed.

URGENCY OF NEED DESIGNATOR (UND) - An alpha designator which signifies the degree of need for the material requisitioned.

WORK STOPPAGE (DUE TO PARTS) - A condition that exists when sufficient parts/material are not available to allow for the continuation of work within a production area. When this occurs, expedited supply actions are required.

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VITA

Steve McBride [redacted] in 1975 and attended the University of Cincinnati, from which he received the degree of Bachelor of Science in Industrial Engineering in June 1981. His experience includes the functions of industrial engineering and material control over three years in depot level maintenance at San Antonio Air Logistics Center and six years at Headquarter Air Force Logistics Command. Steve is registered as a Professional Engineer (PE) by the State of Ohio, as well as certified (CPIM) by the American Production and Inventory Control Society. He entered the School of Systems and Logistics, Air Force Institute of Technology, in June 1987.

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Depot Maintenance attempts ~~makes many efforts~~ to plan parts requirements and to assure adequate stocks are available to meet demands. Nevertheless, many parts with recurring usage never seem to be adequately stocked to support actual requests. ~~The overall direction of~~ this research ~~is to~~ parallels and builds upon research by the A.F. ~~Air Force~~ Logistics Management Center ~~(AFLMC)~~ which ~~AFLMC~~ studied variability of demand at the base-level; this ~~research~~ Thesis investigates variability of demand for Depot Level Maintenance. Its ~~The purpose of this study was threefold~~ was: 1) to determine assumptions made by the MIC (Maintenance Inventory Center) and D033 stockage models in regards to demand; 2) to analyze actual Depot Maintenance parts demands and assess if these assumptions were valid; and 3) to evaluate ~~(simulate)~~ alternative ~~maintenance~~ inventory center ~~(MIC)~~ stockage policies.

Analysis of demands from five MICs indicated demands levied against the aircraft area MIC tended to be constant Poisson in nature. Demands for the non-aircraft areas tended to be more variable and for higher quantities. Research suggested current MIC stockage policy was not capable of providing overall 95 % ~~percent~~ line item fill rates as presented by certain data automation reports. Examination of The D033 ~~(O&ST)~~ safety level equation ~~was~~ also examined and research indicated it did not adequately accommodate observed variance in demand.

Simulations showed the current 30/15 day (stock level/reorder point) policy is good for many expendable items. However, a simulated hybrid lot size and safety level approach can maintain similar line item fill rates and simultaneously reduce stock levels for some items. The simulated 7/3.5 day policy showed the lowest fill rates and highest backorder-days.